

Dec. 5, 1950

A. J. WEINIG
ROTARY ORE CONCENTRATOR

2,533,074

Filed April 12, 1948

3 Sheets-Sheet 1

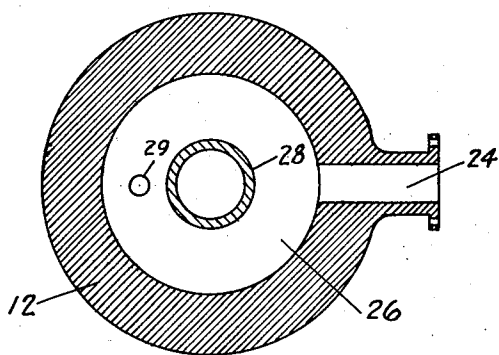


Fig. 5.

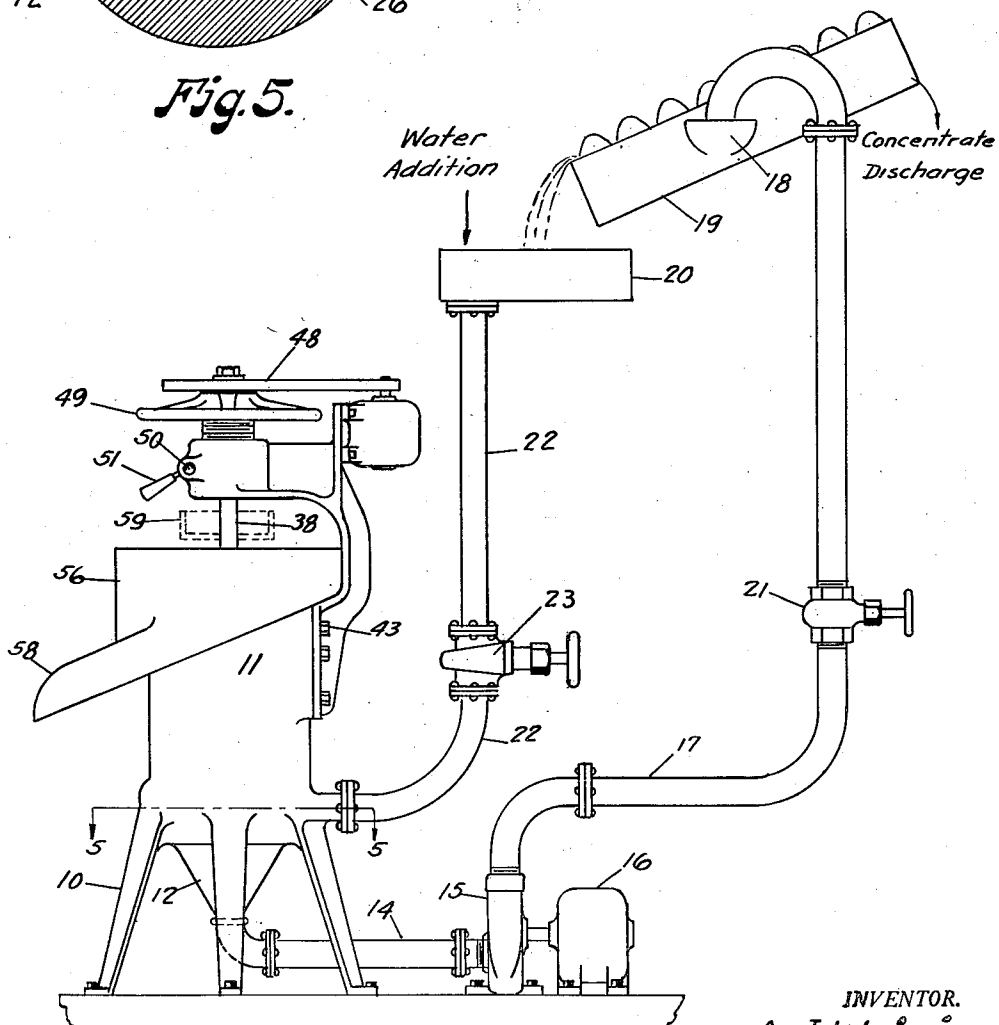


Fig. 1.

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3 Sheets-Sheet 2

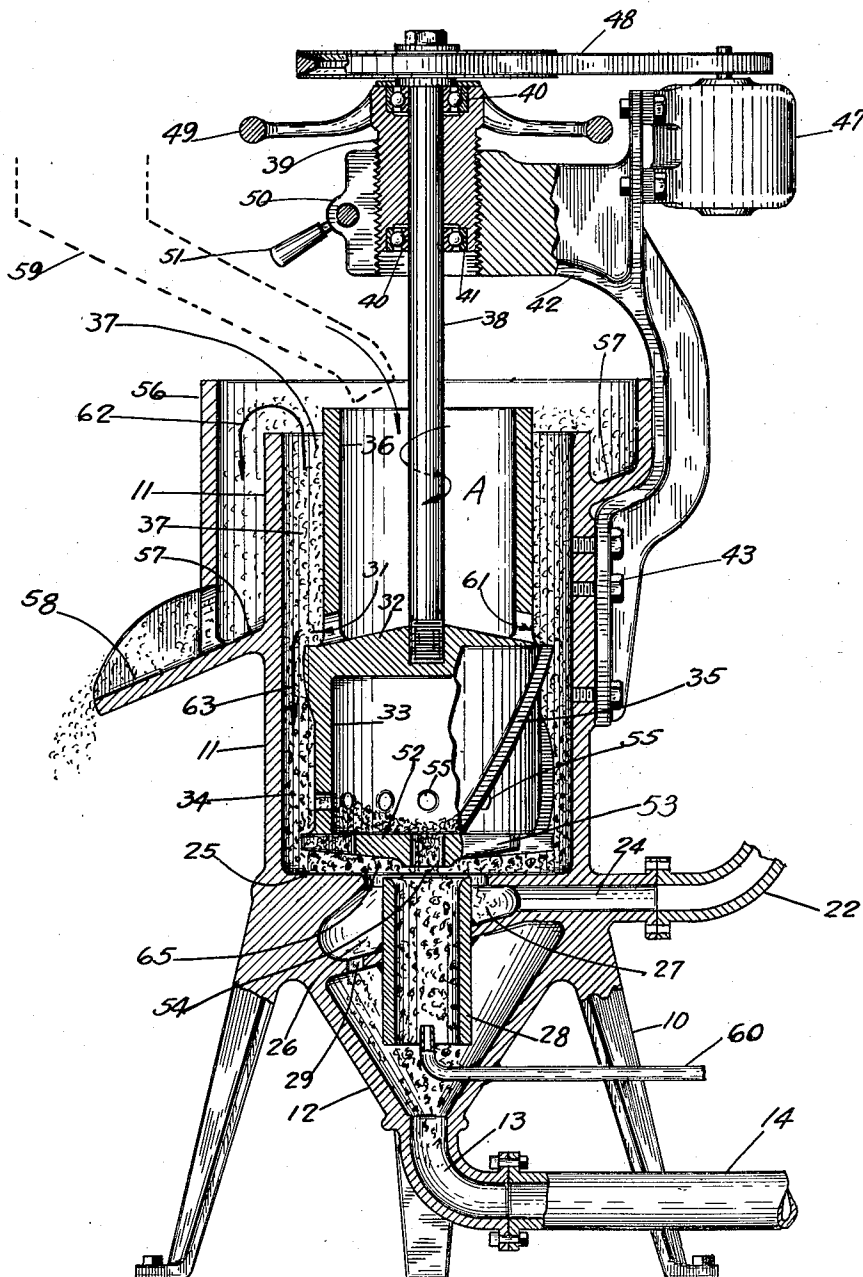


Fig. 2.

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3 Sheets-Sheet 3

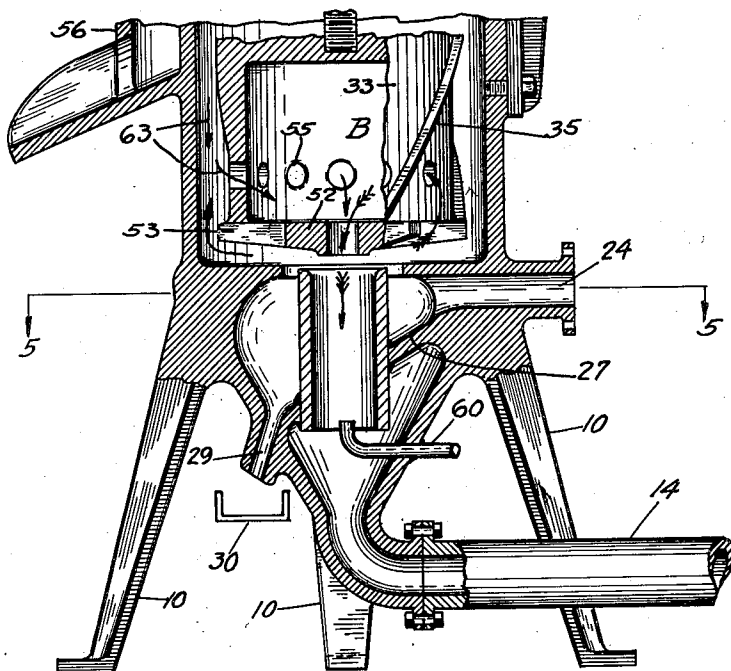


Fig. 3.

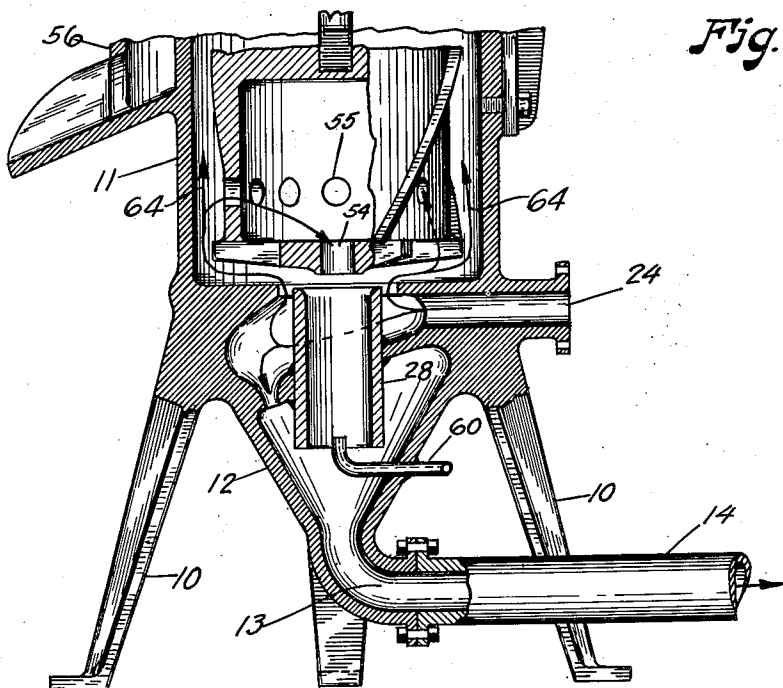


Fig. 4.

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ROTARY ORE CONCENTRATOR

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Application April 12, 1948, Serial No. 20,472

10 Claims. (Cl. 209—159)

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This invention relates to improvements in rotary ore concentrators.

It is the object of this invention to produce a simple, substantial machine for concentrating ores, that shall be highly efficient in its operation and have a large capacity per unit weight.

Another object is to produce a machine of the type mentioned that shall be so constructed that the fines from the centrifugal jiggling and gravity concentration will be recirculated and subjected to a separate and final concentration employing both a downdraft and a centrifugal action.

A further object is to produce a machine of the type specified that can be controlled in its operation to produce a very complete concentration or a coarser one, as may be desired.

A further object is to produce a machine of the type specified in which the fines are subjected as a final step to a down draft.

Another object is to produce a method and an apparatus of such construction that the objectionable "teeter column problem" is eliminated and, as a result, a greater proportion of the finer concentrate recovered.

In order to describe the method and the machine in such a manner that the construction of the machine and its mode of operation can be readily understood, reference will now be had to the accompanying drawings in which the invention has been illustrated and in which:

Figure 1 is an assembly view showing the several parts in side elevation;

Figure 2 is a vertical diametrical section through the separating and classifying device;

Figure 3 is a fragmentary section, similar to that shown in Figure 2, and shows the fine concentrate circuit;

Figure 4 is a section similar to that shown in Figure 3 and shows the water circuit and the position of the fines during operation; and

Figure 5 is a transverse section taken on line 5—5, Figure 3.

Before proceeding with the description of the apparatus, certain terminology hereinafter employed must first be understood. The term "ore" comprises a mixture of particles of two general classes as to specific gravity or density, the first class being the lighter particles such as gangue, of relatively low density, and the second class being heavy particles, or concentrate, of relatively high density. The particles of the concentrate differ in size, the larger forming a coarse concentrate and the smaller a fine concentrate, or fines.

Referring now to the drawing reference numerals 10 designate the legs or base on which the machine is supported. Reference numeral 11 designates a stationary cylindrical casing and reference numeral 12 designates the conical bottom of the casing which will hereinafter at times be referred to as the base. The lower or apex

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end of the conical bottom terminates in a discharge opening 13, that is connected with pipe 14, which connects it with the intake port of concentrate pump 15 that is driven from motor 16. Pipe 17 connects the discharge port of pump 15 with the receiving compartment 18 of the dewaterer 19 which is positioned and arranged to overflow into the steady head tank 20. The flow through pipe 17 is controlled by a valve 21. A pipe 22, provided with a valve 23, connects tank 20 with the hydraulic water inflow opening 24. Interior of casing 11 terminates in a bottom 25 which has a central opening that communicates the interior of the casing with water inlet chamber 26 that has an inclined bottom 27 provided with a central opening through which a short length of pipe 28 extends. The bottom of chamber 26 is also provided with a small port 29 which may be internal as shown in Figures 2 and 4, or external as shown in Figure 3, in the latter case it discharges into a launder 30.

Positioned within casing 11 is a drum 31 that is divided into an upper compartment A and a lower chamber B by a transverse partition 32. Wall 33 of chamber B is somewhat smaller in outside diameter than the inside diameter of casing 11, leaving an annular space forming a sorting or teeter chamber 34 between the two for receiving a lower portion of a teeter column. Wall 33 is provided on its outer surface with a number of helical ribs 35 whose purpose and function will hereinafter appear.

Compartment A is surrounded by wall 36 that is somewhat smaller in outside diameter than wall 33, leaving an annular sorting or teeter chamber 37 that is somewhat larger than space 34 for receiving an upper portion of a teeter column.

The two compartment drum that has just been described is suspended from the lower end of shaft 38 that is mounted for rotation in a bearing block 39 by means of upper and lower antifricition bearings 40. Bearing block 39 has threaded engagement with the wall of opening 41 in the upper end of supporting bracket 42 that is secured to casing 11 by bolts 43.

An electric motor 47 is attached to bracket 42 and transmits rotation to shaft 38 by means of a V-belt 48, or other suitable transmission means. Bearing block 39 is provided with a hand wheel 49 by means of which it may be rotated to raise and lower the drum for adjusting the fineness of the separation in a manner that will later appear. The wall of threaded opening 41 is split and is forced against the outside of bearing block 39 by means of a screw 50 and a handle 51 for locking it in position.

The lower end of wall 33 has attached thereto, by welding or otherwise, a plate 52 that has a plurality of radial impeller blades 53 and a central opening 54. Wall 33 has a row of openings 55,

positioned just behind ribs 35 to prevent choking of the teeter column by the fine concentrate. The upper end of casing 11 is surrounded by a wall 56 that terminates in a spout 58. Water and ore are fed into compartment A through a pipe 59 or through a suitable launder similarly situated. Air is introduced to the lower end of pipe 28 when desired through a pipe 60.

Ribs 35, a few of which are positioned on the outer surface of wall 33, give an upward component to the water and in addition produce a pulsation that results in a jiggling or teetering action which further enhances the concentration.

Since the fines that are separated must all flow downwardly through hole 54 and through pipe 28, when the drum is in its lowermost position, a very thorough separation takes place. By means of hand wheel 49, bearing block 39 may be rotated and the drum raised or lowered. When the drum is raised, more of the fines from annular chamber 34 will pass into pipe 28 without first passing through the toroidal circuit which increases the rate at which the ore is treated.

Let us now assume that the machine which has been illustrated and described is in operation and that the parts are arranged as in Figures 1 and 2. Both motors 16 and 47 are operating and water and ore fed to compartment A through pipe 59. After the dewaterer has been filled with water so that it overflows, the operation commences. The ore that is fed to compartment A flows out through holes 61 into the annular teeter chamber 37 where it meets an upwardly flowing current of water. The water in annular chambers 34 and 37 has a helical path, due to the rotation of the drum and the action of ribs 35. The water and the lighter gangue particles move upwardly and overflow the upper end of wall 11, as indicated by arrow 62. The heavier metalliferous concentrate moves downwardly into annular chamber 34, as indicated by arrow 63. Practically all of the downwardly moving fine concentrate passes through holes 55 into compartment B, following arrows 63, as shown in Figure 3, and finally passes through hole 54. A portion of the aforesaid fine concentrate passes downwardly through pipe 28 and into discharge opening 13, and thence into pipe 14 to pump 15 from which it is elevated to the dewaterer 19. The fine concentrate that does not fall through pipe 28 is recirculated by the action of the impeller blades 53 through a toroidal path and enters a second time into compartment B and leaves through hole 54 where another portion of the fine concentrate discharges through pipe 28 and is similarly delivered to the dewaterer. The path of the water has been indicated by arrows 64 in Figure 4.

It will be recognized that the apparatus described is a rotary ore concentrator of a type early suggested by Wetherbee. See U. S. Patent No. 856,612. In this process the ore particles are kept in horizontal rotary agitation against an upward current of hydraulic water, just sufficient to carry over the top of the container the gangue particles and permit the heavy grains of mineral to settle to the bottom where means are provided for discharge. In the type of apparatus to which U. S. Patent 856,612 belongs, the operation is at its best when the discharge launder or hopper at the bottom is kept full of concentrate so that the discharge is much restricted by the concentrate itself. Under this

condition chambers corresponding to 34 and 65 become filled with heavy solids largely made up of fine concentrate which is unable to settle down through the ascending current of water. Eventually the accumulation is great enough to restrict the void spaces between the coarser concentrate grains through which the ascending hydraulic water travels, to such a degree that the velocity of the water through these spaces becomes great enough to carry the finer grains of concentrate up and over the top of apparatus where they are lost. Such a zone of accumulation is known in the art as a teeter bed or column. It presents a serious problem in all forms of hydraulic concentration and classification.

The present invention has resulted from study of the teeter column problem and offers a solution for the elimination of such column and for the recovery of the finer concentrate ordinarily lost because of the teeter column effects.

The circling flow through opening 54 is positioned over the down draft flow of water in pipe 28 and near the inflow from chamber 26. Here the three flows mentioned coming and a substantial portion of the fine solids from the teeter column is shunted out of the system and recovered; accumulations in the teeter column are thus reduced.

The suspension of fine concentrate in the liquid from the teeter column is due to the violence of the agitation and circulation. Ordinarily these particles are from 28 mesh down to 100 mesh or even finer when very heavy minerals like galena are present.

The coarser concentrate does not follow the circulation within the bottom of the drum but takes a path down through chambers 34 and 65 and then out of the system. This path is the ordinary path taken by the concentrate in this type of concentration, perhaps with the exception that this coarse concentrate discharges from the structure of this invention much cleaner and freer of gangue. It is believed that this is due to the increased hydraulic cleaning effect in chambers 65 and 34 because of the recirculation.

Other structures shown in this invention include rather widely spaced spiral ribs 35 so positioned as to add an upward component to the agitation. This assists in preventing the solids in chamber 34 in becoming compacted and dense. The ribs also provide a shield just behind which openings 55 are placed where it has been found the openings so positioned do not choke with coarse material and where the circulation of the liquid from the teeter column is more free. Further, the ribs establish a frequency of jiggling or pulsation which is impressed on the air chamber B in a peculiar way. Since the vertex of the bottom surface of the air is near opening 54 a gulping action of the frequency mentioned, develops by impeller action as the impeller tends to suck air and then releases it. This causes an expansion and contraction of the air in chamber B which affects the entire pulp contents of the apparatus and enhances the jiggling action.

The combination of recirculation, upward agitation and jiggling yields a very free sorting zone in chamber 34. The specific gravity of the pulp in this zone has never been found greater than 1.75. With most ores sufficient air is held in chamber B without air addition. This probably is maintained by entrained air in the circulating water. However, if necessary a small amount

of air may be added through pipe 60. Only sufficient is needed to maintain the air space in chamber B.

Another feature to be noted is the entry of the hydraulic water through an annular space around the down draft pipe 20. Note that the inlet chamber 26 has an inclined bottom terminating in opening 29. The purpose of this opening is to remove any accumulation of heavy solids which may enter the chamber. These solids ordinarily are only small flakes of iron or bits of other metal and occasionally coarse gold. In the latter case if the gold is in sufficient amount it may be separately recovered by making the opening 29 external as shown in Figure 3.

Still another structure to be noted is means for vertically positioning the rotating drum 31 above the bottom of casing 11. It affords a most sensitive and critical means of adjustment. For example when positioned at the lowest point it is easily possible to extract from the system, only the fine concentrate from the teeter column and under this condition the coarser and heavier ore grain can be discharged out and over the top of the apparatus. The fine concentrate is surprisingly clean and free of gangue.

By raising the drum more and more, coarser and coarser concentrate will be extracted from the chambers 34 and 65 and under ordinary conditions of water inflow in operation it is quite possible to discharge through pipe 28 the entire feed to the machine. However, quite independent of the position of the drum the fine concentrate circuit from the teeter column remains functional and unaffected. It can be readily seen, therefore, that a most sensitive means of adjustment is thus afforded, whereby selection of quality or quantity of product can be quickly attained.

As an example of this performance, a very difficult product known as Patrick Pond tailings from treated taconite iron ores of Cooley, Minnesota, has yielded the following results in experiments to produce therefrom a marketable iron ore concentrate of 58% Fe (iron) with not over 11% SiO₂ (silica). This product is all -4

Opening below Drum	Concentrate Recovered		
	Per Cent Weight ¹	Per Cent Fe	Per Cent SiO ₂
24".....	22.02	62.95	5.79
34".....	40.36	60.34	8.59
44".....	51.08	58.26	10.32

¹ Per cent of the feed weight.

A screen analysis of the concentrate showed the following:

	Per Cent Weight	Per Cent Fe	Per Cent SiO ₂
-4 mesh+28 mesh.....	36.67	58.95	9.19
-28 mesh+48 mesh.....	38.14	59.84	9.50
-48 mesh+100 mesh.....	21.76	63.44	5.70
-100 mesh.....	3.43	60.34	8.59
Total.....	100.00		

In this test having once set the hydraulic water flow to what appeared was the best condition, the various qualities and quantities of concentrate made were produced solely by the positioning the drum above the bottom of casing 11.

Since the Patrick Pond tailings are mainly classifier overflows, special note is to be made of the heavy recoveries made by this process in sizes normally lost from teeter column accumulations.

Having described the invention what is claimed as new is:

1. A method of separating ores containing light particles, such as gangue, a coarse concentrate, and a fine concentrate, comprising; confining a teeter column in a substantially annular zone with the axis of the teeter column disposed substantially vertically, supporting the bottom annular area of the teeter column, applying rotating forces to the inner surface of the teeter column and feeding water into the teeter column producing a spirally upward movement of water in the zone, the upward movement of the water carrying light particles upwardly for discharge from the upper end of the zone and the concentrates moving to the lower end of the zone, by-passing a portion of fine concentrate from the teeter column above its lower end in an inward direction and thence downwardly, discharging coarse concentrate inwardly from the lower end of the teeter column and thence downwardly, recirculating a portion of the downwardly moving fine concentrate into the lower end of the teeter column for passage upwardly therethrough, and discharging a portion of the downwardly moving fine concentrate with the downwardly moving coarse concentrate by the action of an outgoing current of water.

2. An ore concentrator comprising; a hollow rotor mounted for rotation about a substantially vertical axis, the rotor having an opening at its bottom, a casing surrounding the rotor in spaced relation thereto providing a teeter chamber between the rotor and casing for containing a teeter column therein, wall means extending inwardly from the casing below the rotor at the bottom of the teeter chamber for supporting a teeter column thereabove, means for feeding ore and water into the teeter column, aperture means in the rotor disposed above its bottom for permitting fine concentrate in the teeter column to pass inwardly therethrough, discharge means having an opening in the wall means disposed below the bottom of the rotor adapted to receive an outgoing current of water, said wall means and the bottom of the rotor forming a passageway through which a portion of the fine concentrate may recirculate into the lower end of the teeter column for passage upwardly therethrough and through which coarse concentrate may pass to said last named opening, a portion of the fine concentrate being adapted to pass out with the outgoing current of water, and means for recirculating said first named portion of the fine concentrate outwardly through said passageway and into the lower end of the teeter column.

3. An ore concentrator comprising; a hollow rotor mounted for rotation about a substantially vertical axis, the rotor having an opening at its bottom, a casing surrounding the rotor in spaced relation thereto providing a teeter chamber between the rotor and casing for containing a teeter column therein, wall means extending inwardly from the casing below the rotor at the bottom of the teeter chamber for supporting a teeter column thereabove, means for feeding ore and water into the teeter column, aperture means in the rotor disposed above its bottom for permitting fine concentrate in the teeter column to pass

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inwardly therethrough, discharge means having an opening in the wall means disposed below the bottom of the rotor adapted to receive an outgoing current of water, said wall means and the bottom of the rotor forming a passageway through which a portion of the fine concentrate may recirculate into the lower end of the teeter column for passage upwardly therethrough and through which coarse concentrate may pass to said last named opening, a portion of the fine concentrate being adapted to pass out with the outgoing current of water, means for recirculating said first named portion of the fine concentrate outwardly through said passageway and into the lower end of the teeter column, and means for varying the size of said passageway.

4. An ore concentrator comprising; a hollow rotor mounted for rotation about a substantially vertical axis, the rotor having an opening at its bottom, a casing surrounding the rotor in spaced relation thereto providing a teeter chamber between the rotor and casing for containing a teeter column therein, wall means extending inwardly from the casing below the rotor at the bottom of the teeter chamber for supporting a teeter column thereabove, means for feeding ore and water into the teeter column, aperture means in the rotor disposed above its bottom for permitting fine concentrate in the teeter column to pass inwardly therethrough, discharge means having an opening in the wall means disposed below the bottom of the rotor adapted to receive an outgoing current of water, said wall means and the bottom of the rotor forming a passageway through which a portion of the fine concentrate may recirculate into the lower end of the teeter column for passage upwardly therethrough and through which coarse concentrate may pass to said last named opening, a portion of the fine concentrate being adapted to pass out with the outgoing current of water, means for recirculating said first named portion of the fine concentrate outwardly through said passageway and into the lower end of the teeter column, and means for controlling the rate of flow through said discharge means.

5. An ore concentrator comprising; a hollow rotor mounted for rotation about a substantially vertical axis, the rotor having an opening at its bottom, a casing surrounding the rotor in spaced relation thereto providing a teeter chamber between the rotor and casing for containing a teeter column therein, wall means extending inwardly from the casing below the rotor at the bottom of the teeter chamber for supporting a teeter column thereabove, means for feeding ore and water into the teeter column, aperture means in the rotor disposed above its bottom for permitting fine concentrate in the teeter column to pass inwardly therethrough, discharge means having an opening in the wall means disposed below the bottom of the rotor adapted to receive an outgoing current of water, said wall means and the bottom of the rotor forming a passageway through which a portion of the fine concentrate may recirculate into the lower end of the teeter column for passage upwardly therethrough and through which coarse concentrate may pass to said last named opening, a portion of the fine concentrate being adapted to pass out with the outgoing current of water, means for recirculating said first named portion of the fine concentrate outwardly through said passageway and into the lower end of the teeter column, and means for delivering water into said passageway.

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6. An ore concentrator comprising; a hollow rotor mounted for rotation about a substantially vertical axis, the rotor having an opening at its bottom, a casing surrounding the rotor in spaced relation thereto providing a teeter chamber between the rotor and casing for containing a teeter column therein, wall means extending inwardly from the casing below the rotor at the bottom of the teeter chamber for supporting a teeter column thereabove, means for feeding ore and water into the teeter column, aperture means in the rotor disposed above its bottom for permitting fine concentrate in the teeter column to pass inwardly therethrough, discharge means having an opening in the wall means disposed below the bottom of the rotor adapted to receive an outgoing current of water, said wall means and the bottom of the rotor forming a passageway through which a portion of the fine concentrate may recirculate into the lower end of the teeter column for passage upwardly therethrough and through which coarse concentrate may pass to said last named opening, a portion of the fine concentrate being adapted to pass out with the outgoing current of water, means for recirculating said first named portion of the fine concentrate outwardly through said passageway and into the lower end of the teeter column, and means for adding air to the inside of the rotor.

7. A rotary concentrator comprising, a stationary substantially cylindrical housing having a discharge outlet at its lower end, a bearing positioned above the housing in axial alignment therewith, a shaft mounted for rotation in the bearing, means resisting forces tending to move the shaft axially in the bearing, a cylindrical drum secured in axial relation to the lower end of the shaft, within the housing, the outside diameter of the drum being less than the inside diameter of the housing whereby an annular teeter chamber is formed between the two, means for feeding ore onto the top wall of the drum while it is rotating, the lower end of the drum having a closure provided with a central opening and a plurality of radial impeller blades, the peripheral wall of the drum having a plurality of holes above and adjacent the lower end closure, a tubular discharge pipe positioned below the central opening of the lower end closure, and means for feeding water into the housing below the lower end of the drum and into the space surrounding the discharge pipe, whereby the liquid from the teeter chamber will be recirculated by the action of the rotating drum and subjected to a concentrating action by the upward flow of water.

8. A rotary concentrator comprising, a stationary substantially cylindrical housing having a discharge outlet at its lower end, a bearing positioned above the housing in axial alignment therewith, a shaft mounted for rotation in the bearing, means resisting forces tending to move the shaft axially in the bearing, means for adjusting the bearing and shaft vertically, a drum secured to the lower end of the shaft, within the housing, the drum having a transverse partition dividing it into an upper and a lower chamber, the outside diameter of the drum being less than the inside diameter of the housing whereby an annular teeter chamber is formed between the two, the wall of the upper chamber having a plurality of openings adjacent the transverse partition, means for feeding ore into the upper chamber, means for rotating said shaft and drum, the lower end of the lower chamber having a closure

provided with a center opening and a plurality of radial impeller blades, the wall of the lower chamber having a plurality of holes above and adjacent the closure, a tubular discharge pipe positioned below the center opening in the closure, and means for feeding water into the housing below the lower end of the rotating drum and into the space surrounding the discharge pipe, whereby the liquid from the teeter chamber will be recirculated by the action of the lower portion of the drum and subjected to the concentrating action of the upward flow of water.

9. A machine for separating ore, comprising, in combination, a base, an upwardly opening cylindrical receptacle supported thereon, a bracket extending upwardly from said receptacle, the upper end of said bracket having an opening coaxial with the receptacle, a bearing in said opening, means for adjusting the position of the bearing axially, a shaft mounted for rotation in the bearing, means resisting forces tending to move the shaft longitudinally in the bearing, a drum of substantially cylindrical cross section, secured to the lower end of the shaft and positioned in the receptacle, said drum having a transverse partition dividing it into an upper and a lower chamber, the wall of the upper chamber having a plurality of openings adjacent the upper surface of the partition, the lower end of the lower chamber having a closure provided with a center opening and a plurality of impeller blades, the wall of the lower chamber having a plurality of openings above and adjacent the closure, the outside diameter of the drum being less than the inside diameter of the receptacle whereby an annular sorting chamber is formed, means for flowing water upwardly through the sorting chamber, a tubular discharge outlet underneath the center opening of the bottom of the lower chamber, and means for feeding ore and water to the upper chamber.

10. An ore concentrating and separating machine comprising, in combination, a base having a downwardly tapering compartment separated into an upper and a lower chamber by a partition having an opening concentric therewith, a section of pipe passing through the opening, coaxial with the conical compartment, the upper end of the upper chamber having an inwardly directed

flange whose opening is larger than the outside of the pipe forming an annular water outlet, means for introducing water into said upper chamber, a cylindrical receptacle extending upwardly from the top of the conical base, a bracket projecting upwardly from the cylindrical receptacle having its upper end overhanging the receptacle, a threaded opening in said upper end, coaxial with the receptacle, a tubular bearing block in said opening mounted for rotation and axial adjustment therein, means for clamping said bearing, a shaft mounted for rotation in the bearing block, means resisting forces tending to move the shaft axially in the bearing, a substantially cylindrical drum secured to the lower end of the shaft for rotation within the receptacle, the outside diameter of the drum being less than the inside diameter of the receptacle providing an annular sorting chamber, the drum being divided into an upper chamber and a lower chamber by a transverse partition, the wall of the drum having a plurality of openings adjacent the upper surface of the partition, the lower end of the lower chamber of the drum having a closure provided with an opening concentric therewith, said closure having a plurality of radial impeller blades, the wall of the lower chamber having a plurality of openings positioned between the partition and the closure, the wall of the lower chamber being otherwise imperforate, means for feeding ore to the upper chamber in the drum and simultaneously flowing a stream of water upwardly through the sorting chamber, and means for turning the drum.

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