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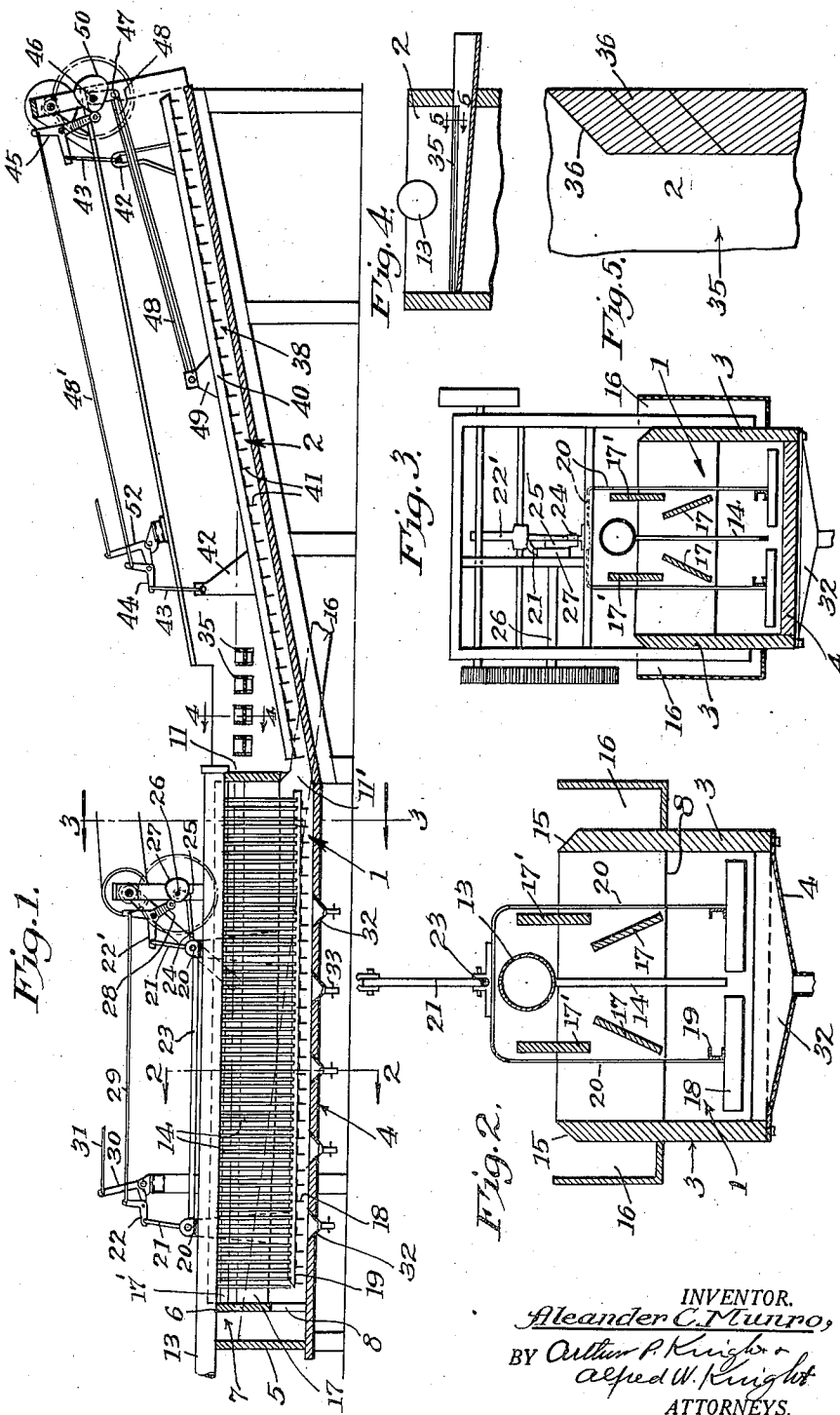
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2,065,722

CLASSIFICATION OF MINERALS

Filed June 15, 1934

3 Sheets-Sheet 1



INVENTOR.  
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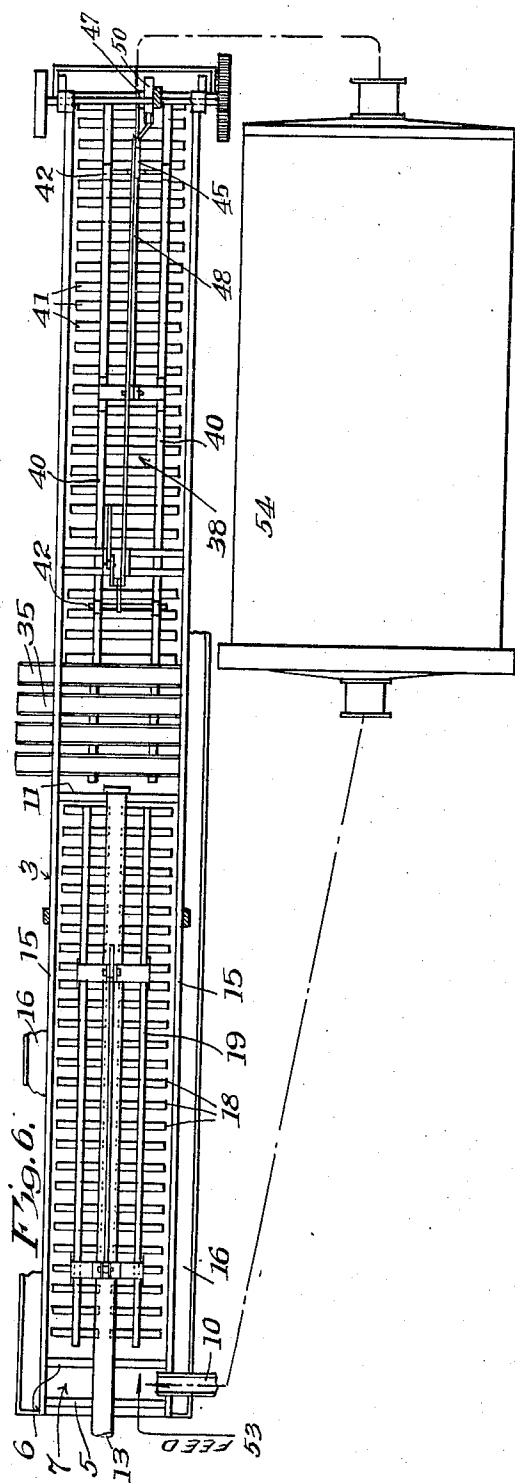
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3 Sheets-Sheet 2



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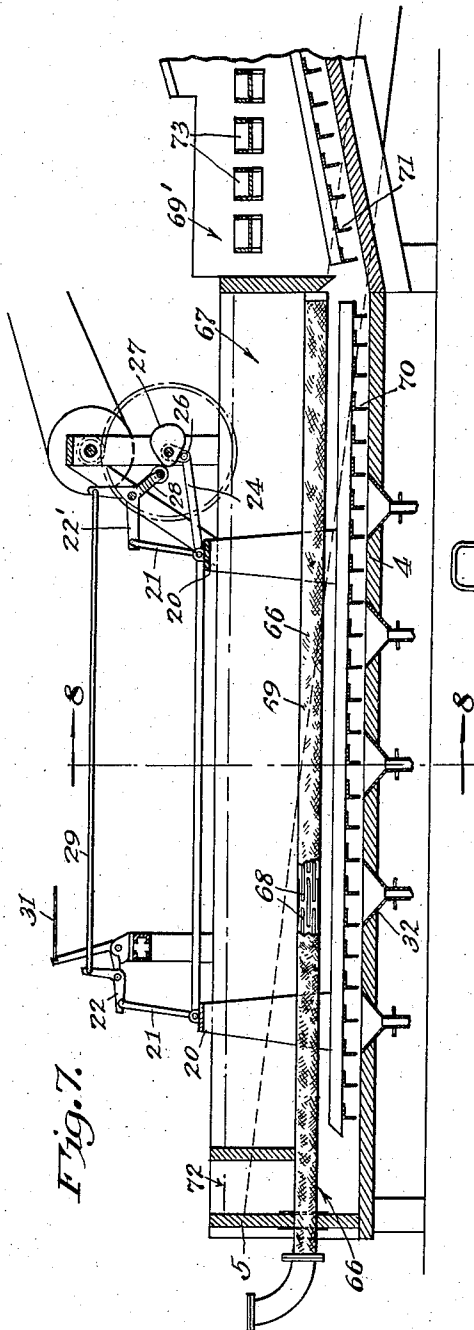


Fig. 7.

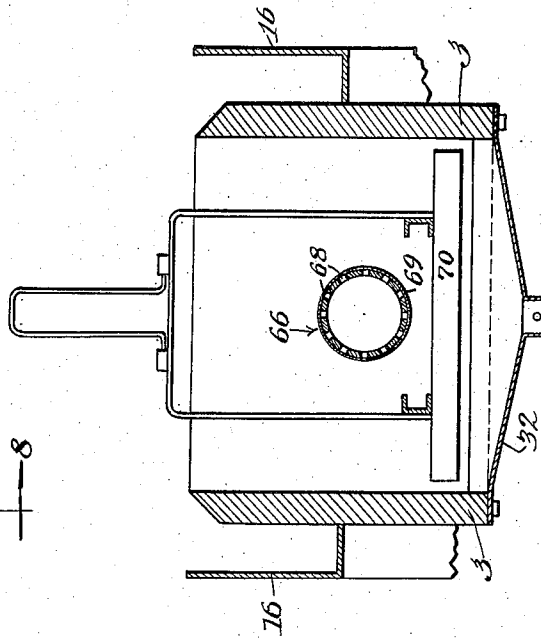


Fig. 8.

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## UNITED STATES PATENT OFFICE

2,065,722

## CLASSIFICATION OF MINERALS

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Application June 15, 1934, Serial No. 730,763

4 Claims. (Cl. 209—18)

This invention relates to improvements in the concentration of ores or other minerals and the main object of the invention is to provide for effective and economical concentration by combined flotation and classifying operations.

An important object of the invention in connection with concentrating operations involving classification and grinding in closed circuit is to reduce the amount of material to be ground by suitable utilization of flotation in connection with such operations.

A further object of the invention is to provide for decreasing the dilution or increasing the thickness of the pulp in a classifying operation and particularly in a combined flotation-classifier operation. Another object of the invention is to provide for increasing the capacity of a flotation-classifier apparatus by removal of the slimes at a suitable stage in the operation.

An important feature of the present invention in connection with a flotation classifier, is that the material to be subjected to flotation and classification is delivered first to the flotation compartment in such manner that the pulp undergoing flotation and the settled solids are caused to move in the same direction through the flotation compartment.

The accompanying drawings illustrate embodiments of my invention and referring thereto:

Fig. 1 is a longitudinal vertical section of a flotation classifier provided with my improvement;

Fig. 2 is a section on line 2—2 in Fig. 1;

Fig. 3 is a section on line 3—3 in Fig. 1;

Fig. 4 is a section on line 4—4 in Fig. 1;

Fig. 5 is a partial section on line 5—5 in Fig. 1;

Fig. 6 is a plan view of the apparatus shown in Fig. 1, a grinding mill being shown in closed circuit with the flotation classifier apparatus;

Fig. 7 is a partial longitudinal section of another form of the invention showing a modified means of supplying air to the flotation compartment;

Fig. 8 is a section on line 8—8 in Fig. 7.

The form of the invention shown in Figs. 1 to 6 comprises a trough or trough-shaped tank or box provided with a flotation compartment 1, preferably extending substantially horizontally and a classifying or discharge rake compartment 2, preferably extending obliquely upward from one end of the flotation compartment. The flotation compartment is provided with side walls 3, with a horizontally extending floor 4 and is closed at one end by a vertical end wall 5. A baffle plate 6 is mounted near the end wall 5 and is spaced from the end wall 5 and floor 4 so as to form an inlet or feed passage 7 between said baffle 6 and end wall 5

and communicating with the compartment 1 through the passage 8 between the bottom of baffle means 6 and the floor 4. Suitable means such as a launder as shown at 10 in Fig. 6 may be provided for supplying to the inlet passage 7 the pulp or mixture of crushed or ground ore and water which is to be treated. A baffle 11 is preferably provided at the other or discharge end of the tank-compartment 1 to permit pulp to flow from compartment 1 into compartment 2.

Suitable means are provided for subjecting the pulp while in tank-compartment 1 to a flotation operation for floating mineral concentrates therefrom and suitable means are also provided for mechanically advancing the heavier portions of pulp along the floor of compartment 1 and into the intake end of compartment 2. The means for effecting flotation may be of any desired type. The form shown in the drawings comprises an air pressure line 13 connected to any suitable source of compressed air or other compressed gas and pipes 14 extending downwardly from said air pressure line or pipe to within a short distance of the bottom of compartment 1. The side walls 3 of compartment 1 are formed with overflow lips 15, preferably beveled, over which the froth may flow into launders 16 arranged at each side of the compartment 1 and leading to any suitable means for receiving the froth concentrates. Baffles 17 and 17' may be provided for suitably controlling the circulation of the pulp.

The means for mechanically advancing the heavier portions of the pulp along the floor of compartment 1 may comprise rakes each provided with raking blades 18 mounted on rake bars 19 which are suspended by hangers 20 and links 21 from supporting levers 22 and 22' and are reciprocated by link connections 23 and 24 with an operating crank means 25 carried by an operating shaft 26. Said shaft is also shown as provided with cam means 27 operating an arm 28 on lever 22' said lever being connected by link 29 to lever 22 so that said levers operate in unison to lift the raking means during its rearward traverse or stroke in the usual manner of raking devices of this character. Lever 22 is shown as pivotally mounted on an angle lever 30 which may be connected by link or cable 31 to a suitable windlass or other means, not shown, for adjusting the height or level of the raking means.

In connection with the flotation tank or compartment as above described, I prefer in some cases to provide means for trapping or retaining heavy concentrates or mineral values, for example, gold, as the material is raked over the bottom compartment. For this purpose a series of traps may be provided in said floor, each trap being formed as a groove or trough 32 extending transversely of or across the floor 4 and pro-

vided with walls which flare upwardly both in a direction transverse to compartment 1 and longitudinally thereof. Each of said traps is preferably provided with discharge gates or valves 33 which may be operated by gravity in the usual manner so as to open automatically upon accumulation of a certain weight of material or they may be opened from time to time by hand if desired.

Means are also provided for removing slimes or finely divided tailings from the pulp, said means comprising a plurality of launders 35 which are preferably arranged in the compartment 2 adjacent the passage 11' below the baffle 11, said launders being shown as extending transversely of said compartment to and through a side wall of said compartment so as to deliver the slimes to any suitable receiving means. These launders deliver the slimes separately from the concentrates delivered by the launder of the flotation classifier, the slimes being in the nature of tailings and being generally rejected as waste. In order to provide for adjustment of the operation of these launders, each of said launders on each side thereof may be provided with an overflow lip means consisting, for example, of a plurality of superimposed bars or strips 36 which are preferably beveled as shown and are removably supported on the side of the launder in any suitable manner so that the overflow level at the lips of said launder may be varied according to requirements. By providing a plurality of such slimes overflow launders each having an overflow lip at each side thereof, the capacity of the apparatus for drawing off slimes may be multiplied to any desired extent thereby increasing the effective capacity of the apparatus and also increasing the thickness of the pulp carrying the slimes.

In the compartment 2 is provided a discharge raking means 38 which may be similar in operation and construction to the discharge raking means in compartment 1, said discharge raking means comprising rake bars 40, raking blades 41 mounted on said raking bars, hangers 42 connected to said rake bars and supported by links 43 from levers 44 and 45. An operating shaft 46 carries a crank 47 which is connected by connecting rod 48 to an arm 49 on a rake means and said shaft also carries a cam 50, operating lever 45, and through link connection also operating lever 44 so as to raise the raking means in its rearward stroke. Means indicated at 52 are also preferably provided for adjusting the level of the raking means in compartment 2. The operation of the raking means in the respective compartments is such that each rake is given a forward movement while in depressed position as to rake the heavier material upwardly along the floor of the compartment and then at the end of the rearward stroke is lowered to effect the raking position for the next forward stroke.

The operation of the apparatus shown in Figs. 1 to 6 is as follows:

The pulp containing suitably divided ore or other mineral together with water and a flotation agent is supplied as indicated at 53 to the inlet passage 8 leading to the lower part of the flotation compartment and flows longitudinally through said flotation compartment to the discharge passage 11' leading to the compartment 2. In passing longitudinally in the compartment 1 the pulp is subjected to a flotation operation by the action of the air issuing from the pipes 14, this operation resulting in agitation of the pulp

in formation of bubbles or froth and in flotation of mineral or ore concentrates which are taken up by the froth and discharged into the launders 16 which convey such froth concentrates to any suitable receiving means. The larger or heavier particles in the pulp tend to settle to the floor of compartment 1 and are there subjected to a raking operation by the raking means 18 so as to be progressively advanced from the intake passage 8 to the discharge passage 11' and in this operation all portions of the pulp are successively subjected to the operation of the flotation means so that the pulp which passes through the discharge passage 11' comprises substantially only material which is not susceptible to flotation either by reason of its surface characteristics or by reason of it being in insufficiently divided condition. The nonfloatable finely divided constituent of the pulp constituting the slimes, is removed at the overflow launders 35 which are in sufficient number and have sufficient overflow lip capacity to provide for removal of any desired proportion of the slimes from the pulp before the heavy or coarser portion of the pulp is drawn out of the liquid in the tank by the operation of the discharge raking means 38. In this connection it may be stated that the operation of the classifier means 41 not only draws the heavier material longitudinally and upwardly out of the body of liquid, but also agitates the body of liquid so as to aid in keeping the slimes in suspension and thus insuring overflow of slimes at the launders 35.

The slimes are removed from the classification compartment 2 by means of the launders 35, these launders being provided in such number that substantially the entire volume of water supplied to the flotation compartment is removed from the classification compartment through said launders, it being understood that a small proportion of the supplied water will be contained in the froth discharged from the flotation compartment. The provision of a plurality of launders 35 provides an extended length of overflow lip so that the height of fluid pouring over the lip may be kept as short as possible. In the use of an extended overflow lip as at present provided by the plurality of launders 35, a relatively thick pulp may be handled as compared to the pulp concentration practically employable in rake classifiers of the described type which are provided with the conventional side launders, and thus the handling capacity of the apparatus is materially increased. It will be appreciated that the multiple launders 35 are actually a part of the classifier compartment 2, and are useful in connection with a classifier operating either with or independently of a flotation compartment.

The reciprocating motion of the raking means 38 causes an appreciable movement of the liquid in the classifying compartment, but due to the opening or discharge passage 11', the force or surge of this liquid movement is diminished by virtue of the body of liquid within the flotation compartment. This feature prevents the customary disturbing surge adjacent the slimes overflow launders which is so characteristic of raking type classifiers due to the reflection of this surge against the end wall of the classifier tank corresponding to the baffle 11, and according to this invention a relatively quiet zone is provided adjacent the launders 35 so that the overflow level of the slimes may be preserved substantially constant, and a more

uniform and efficient classifying action obtained.

The coarser portions of the material being operated upon are subjected, after entering compartment 2, to the raking action of the raking means 38 whereby they are moved upwardly along the floor of said compartment and finally discharged at the upper end of said floor to any suitable receiving means, for example, to a suitable launder or other means whereby such material is conducted to the grinding mill indicated at 54, the broken lines indicating the course of material from the discharge end of compartment 2 to the grinding mill and back from the grinding mill to the inlet 10 of the compartment 1.

In the above described apparatus the suitably crushed ore coming from the mill and including the ground feed and reground material is supplied at the end of the compartment opposite the raking-off or classifier compartment so that the flow of pulp proceeds in the same direction as the motion of the heavier material under the operation of the rakes, while the removal of the slimes tailings is effected after the pulp has passed through the flotation operation. The advantages of this method of operation are as follows:

No sulphide material is ground unnecessarily fine and the flotation capacity for a given fine material is thereby increased. In Patent No. 1,937,837 issued to me December 5, 1933, a flotation classifier apparatus is disclosed in which the flow of pulp through the flotation compartment is counter-current to the advance of the settled material under the operation of the raking means. The provision for concurrent flow instead of the counter-current flow has certain marked advantages as above stated. A further advantage of the operation of the above-described apparatus in which the flow of pulp is concurrent (in the sense of direction) with the advance of the settled coarse material, is that it avoids the loss of fine gangue particles containing sulphide values which have neither floated nor settled by gravity to the bottom of the compartment in position to be acted upon by the raking means. It will be appreciated that there is considerable agitation of the pulp in the flotation compartment and such unfloatable particles as are not sufficiently large or heavy to overcome the agitation effects will be kept in suspension in the pulp, and where such particles are carried directly to the slimes overflow launders as in the case of the showing in my U. S. Patent No. 1,937,837, they are lost with the slimes, while according to the present preferred showing such particles are carried into the classification compartment where they are in position to freely settle toward the classifying rakes, by which they are gently trapped and raked toward the discharge leading to the grinding mill.

Other important advantages of the present invention are as follows:

Reduction of tonnage to be ground, thus effecting as saving of grinding media consumption and power; increase in flotation capacity which is obtained by eliminating sliming of the mineral particles such as occurs in existing classifiers wherein the pulp is ground unduly fine before being subjected to flotation. Over-sliming of the mineral which always occurs in the conventional practice not only retards flotation and thus greatly reduces the capacity of the flotation apparatus, but it increases greatly

the cost of subsequent operations of recleaning, dewatering and refiltering the flotation concentrate. By means of the multiple lip overflow for the slimes, the mineral values having already been removed in the flotation operation, a very efficient classification is enabled in the classifier compartment 2. Moreover, as above pointed out, the use of the multiple lip overflow for the slimes tailings enables the use of a much thicker pulp in the classifying operation. As a direct consequence of such thick pulp, the use of bowl classifiers on the withdrawn slimes may in some cases be entirely eliminated. This form of slimes overflow also enables the production of lower final tailings and also enables reduction of the floor space required for a given capacity.

The provision of the gold traps or heavy material traps in the bottom of the classifier compartment is of special advantage where the ore or material being treated contains gold or other heavy material which is amenable to separation by such traps, inasmuch as it enables separation of coarse free gold particles and their recovery by intermittent cleaning of the gold traps without disturbing the continuous operation of the flotation classifier, and furthermore it insures removal and recovery of such free gold particles before the heavy settled material is returned to the mill, thereby avoiding the loss which would result from regrinding if such free gold particles were allowed to be attritioned in the grinding mill. In this connection, the agitation or circulation due to the operation of the flotation means and to the operation of the raking means in the flotation compartment cooperates effectively with the gold traps in enabling settling of the heavy gold particles in such traps and the displacement of lighter gangue particles from such traps, thereby facilitating the separation and recovery of the gold or other heavy material. The classifying compartment is without any outlet for liquid at its lower portion and the slimes overflow means 35 constitutes substantially the sole means for discharge of liquid from said compartment, the settled material being discharged from said compartment by operation of the mechanically operated means which moves the settled material upwardly out of the body of liquid, without removing any substantial amount of liquid.

Any suitable means may be provided for supplying air to the flotation compartment so as to effect the flotation operation. Thus, as shown in Figs. 7 and 8, the aerating means may comprise a pipe 66 connected to a suitable source of compressed air and extending longitudinally within the flotation compartment 67, said pipe being provided with perforations or slots 68 and with a porous or pervious fabric or other covering 69 around said pipe so that the air issuing from the pipe will be distributed into the body of the pulp in such manner as to insure collective circulation and flotation. The construction of the flotation compartment 67 and classifying compartment 69 and the respective raking means 70 and 71 with their operating means may be similar to that above described and the heads inlet 72 and the slimes overflow 73 may be provided as shown in Fig. 7.

I claim:

1. An ore concentrating apparatus comprising: a tank including a froth flotation compartment and a classifying compartment con-

5 tiguous to one end of said flotation compartment  
and in free communication therewith through  
an opening adjacent the bottom of said com-  
partments; means for supplying divided solid  
10 material and liquid to the other end of said flo-  
tation compartment; overflow means for said  
flotation compartment for receiving and dis-  
charging flotation concentrates therefrom; me-  
chanically operated means at the bottom of  
15 said flotation compartment for mechanically  
moving settled material through said compart-  
ment toward and through said opening and into  
said classifying compartment; reciprocating rake  
means in said classifying compartment for me-  
20 chanically moving settled material through said  
compartment and away from said opening under  
conditions of agitation and for discharging said  
settled material from said compartment; over-  
flow means in said classifying compartment for  
25 maintaining a liquid level in both of said com-  
partments and for removing liquid containing  
solids in suspension from said classifying com-  
partment, said overflow means being disposed  
at the end of said classifying compartment ad-  
30 jacent said flotation compartment; and means  
for conducting away settled material discharged  
from said classifying compartment, wholly sepa-  
rate from material removed at said overflow  
means.

30 2. An ore concentrating apparatus compris-  
ing: a froth flotation compartment; means for  
supplying divided solid material to be treated  
to one end of said compartment together with  
liquid, said flotation compartment being pro-  
35 vided with overflow means for receiving and dis-  
charging flotation concentrates therefrom and  
being further provided with an opening at the  
other end thereof adjacent the bottom thereof;  
a classifying compartment communicating at one  
40 end with said flotation compartment through  
said opening and provided with a bottom wall  
inclined upwardly away from said opening;  
mechanically operated means at the bottom of  
said flotation compartment for mechanically  
45 moving settled material therethrough in a di-  
rection away from said one end toward and into  
said classifying compartment through said open-  
ing; reciprocating rake means in said classifying  
compartment for mechanically removing  
50 settled material upwardly along said inclined  
bottom wall and away from said opening under  
conditions of agitation and for discharging said  
settled material from said compartment; over-  
flow means in said classifying compartment ad-  
55 jacent said one end thereof for removing liquid  
containing solids in suspension from said classifying  
compartment and for maintaining a liquid  
level in both of said compartments; and means  
for conducting away settled material discharged  
60 from said classifying compartment, wholly sepa-  
rate from material removed at said overflow  
means.

3. An ore concentrating apparatus compris-  
ing: a horizontally elongated tank adapted to  
65 hold a body of liquid; means defining a liquid  
level within said tank; baffle means intermediate  
the ends of said tank extending downwardly  
from adjacent said liquid level and having its  
lower end spaced from the bottom of said tank,  
70 and defining a froth flotation compartment at  
one side of said baffle and a classifying compart-

ment at the other side of said baffle and pro-  
viding a communicating opening therebetween,  
the bottom wall of said classifying compartment  
sloping upwardly from adjacent said opening to  
one end of said elongated tank; means for sup-  
5 plying divided solid material and liquid to the  
other end of said elongated tank at the end of  
said flotation compartment away from said baffle  
means; overflow means for said flotation com-  
partment for receiving and discharging flotation  
10 concentrates therefrom; mechanically operated  
means at the bottom of said flotation compart-  
ment for mechanically moving settled material  
toward said baffle means and into said classifying  
compartment through said opening; recipro-  
15 cating rake means in said classifying compart-  
ment for mechanically removing settled material  
outwardly of said classifying compartment along  
said upwardly sloping bottom wall and discharg-  
ing said settled material from said compartment;  
20 said liquid level defining means comprising over-  
flow means in said classifying compartment ad-  
jacent said baffle means for removing liquid con-  
taining solids in suspension from said classifying  
compartment; and means for conducting away  
25 settled material discharged from said classifying  
compartment, wholly separate from material  
removed at said overflow means.

4. An apparatus for separating the solid con-  
stituents of an ore pulp containing water and  
30 divided solids into a flotation concentrate por-  
tion, a slimes portion, and a settled coarse por-  
tion, and for separately discharging said three  
portions, comprising: a horizontally extending  
flotation compartment; means for supplying such  
35 a pulp to one end of said flotation compartment;  
said flotation compartment being provided with  
overflow lip means for discharge of flotation con-  
centrates and means for separately conducting  
away concentrates so discharged, and being also  
40 provided with an opening adjacent the bottom  
thereof at the end opposite said one end for  
outflow of the unfloatable solid and liquid con-  
stituents of said pulp; means for aerating the  
pulp in said flotation compartment; mechanically  
45 operated means at the bottom of said compart-  
ment for moving settled material from said one  
end toward and through said opening; a classifying  
compartment disposed contiguous to said  
opposite end of the flotation compartment and  
50 communicating therewith through said opening,  
so as to receive said unfloatable constituents; said  
classifying compartment being provided with  
overflow means for maintaining a liquid level  
in both of said compartments and for discharg-  
55 ing water containing suspended slimes, and with  
means for separately conducting away water and  
slimes so discharged, said overflow lip means  
constituting substantially the sole means for  
outflow of water from said classifying compart-  
60 ment; mechanically operated means in said classifying  
compartment for removing settled material  
therefrom and discharging said settled material,  
substantially free from water, at a position  
above said liquid level; and means for con-  
65 ducting settled material so discharged away from  
said classifying compartment, wholly separate  
from said flotation concentrates and from water  
and slimes discharged at the last-named overflow  
lip means.

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