May 6, 1941. G. SBORLINO 2,240,671

APPARATUS FOR THE CONCENTRATION OF MINERALS

Filed April 20, 1939 2 Sheets-Sheet 1

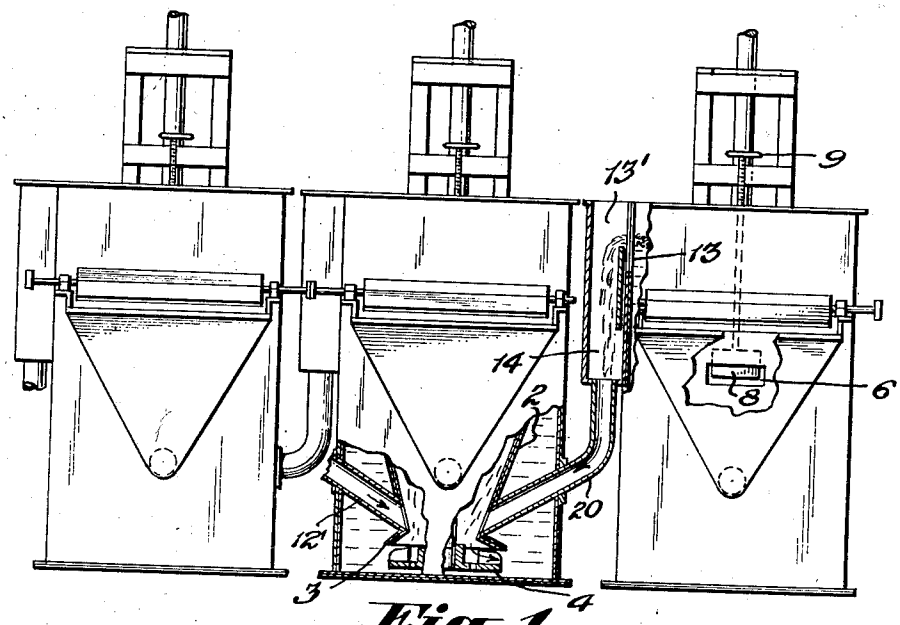

Fig. 1.

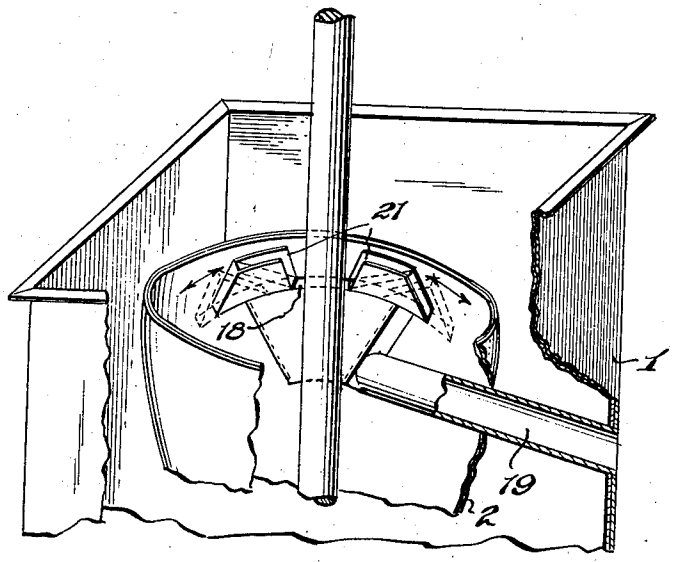

Fig. 4.

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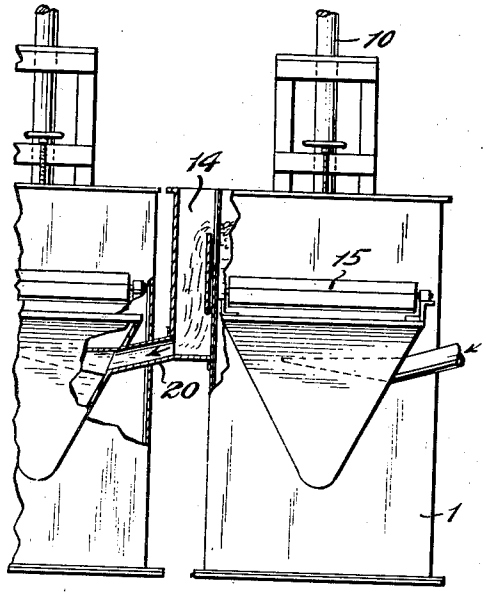


Fig. 5.

Fig. 6.

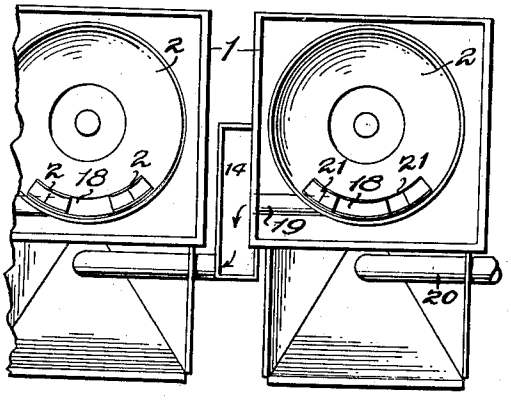


Fig. 2.

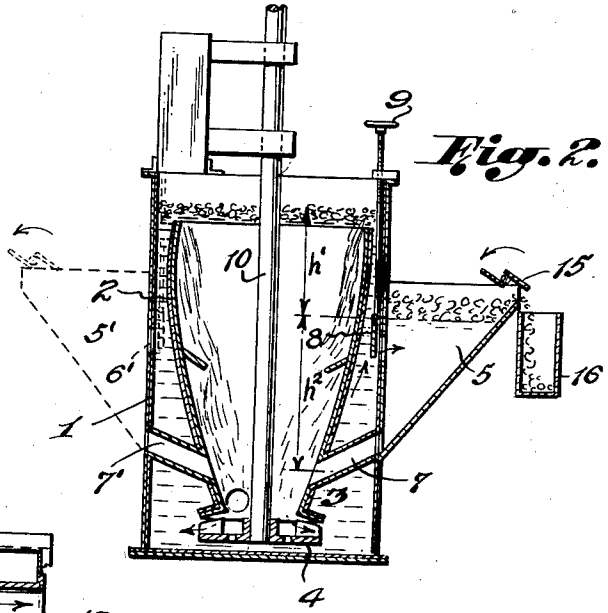
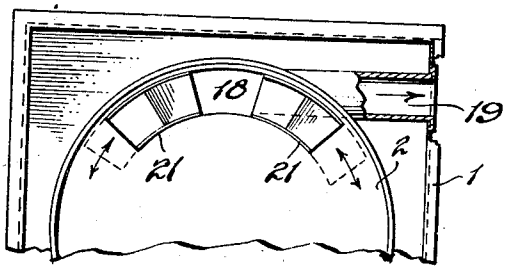


Fig. 3.



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UNITED STATES PATENT OFFICE

2,240,671

APPARATUS FOR THE CONCENTRATION OF MINERALS

Gino Sborlino, Milan, Italy

Application April 20, 1939, Serial No. 269,027
In Italy May 5, 1938

5 Claims. (Cl. 209—169)

This invention relates to improvements in apparatus for concentrating minerals by the froth-flotation method.

The invention consists of a flotation apparatus of the mechanically agitated type comprising an upright agitating chamber (preferably rectangular) having a horizontal rotary agitator near the bottom of the chamber and having a concentric funnel shaped vessel of such dimensions and located within the chamber so that the lower open end of the funnel almost touches the blades of the agitator whilst the upper open end of this vessel has a diameter slightly less than that of the agitating chamber. Adjacent to this agitating chamber and separated from it by a solid wall, is a frothing chamber of the spitkasten-type connected to the agitating chamber by means of two openings in the said wall, an upper one communicating with the space outside the funnel shape vessel and a lower one near the bottom of the frothing chamber communicating through a pipe with the space inside the funnel-shape vessel.

The main object of the present invention is to accelerate the flotation process and this object is attained by creating in the said flotation apparatus two separate and independent pulp circuits; one, which may be termed the "frothing circuit" is set up between the agitating chamber and the frothing chamber by means of the above mentioned upper and lower communications between both chambers and its purpose is to bring the agitated pulp rapidly and repeatedly out of the turbulent zone of the agitating chamber into the quiet zone in the frothing chamber where the formation of the froth will not be disturbed or hindered.

The second pulp circuit which may be termed the "aerating circuit" is set up in the agitating chamber itself in such a manner, that the interior of the funnel shaped vessel is constantly kept empty by the sucking action of the agitator whilst the pulp level in the agitating chamber is kept at such a height that a thin veil of pulp is constantly cascading back into the interior of the funnel thereby becoming supersaturated with air like a waterfall.

Another object of this invention is to reduce the power consumption of flotation apparatus which object is attained firstly by the absence of any baffles or grids in the agitating chamber—which in other apparatus of this type prevents the free movement and flow of the ore pulp and thereby causes increased power consumption—and secondly, by the agitator being shaped and mounted in the apparatus like the impeller of a centrifugal pump.

The accompanying drawings illustrate by way of example several embodiments of the invention in which:

Fig. 1 is an elevation partly in section of an apparatus constructed in accordance with the invention;

Fig. 2 is a vertical transverse sectional view through one of the agitating chambers;

Fig. 3 is a fragmentary detailed view partly in section of a modification of the invention;

Fig. 4 is a fragmentary perspective view of the device shown in Fig. 3;

Fig. 5 is an elevation partly in section of a modification of the arrangement shown in Figs. 1 and 2;

Fig. 6 is a top plan view of the arrangement shown in Fig. 5.

The agitating chamber 1 (Fig. 2) is of prismatic shape with rectangular cross-section but it can also be of cylindrical shape. In this chamber is arranged a vessel 2 hereinafter referred to as a funnel, of cylindrical or cylindrical-conical or oval shape with an upper opening of a diameter only a little smaller than that of the agitating chamber 1 whilst the lower end opens into the impeller 4. This funnel at its lower end has a bell-shaped rim 3.

The impeller-shaft is coaxial with the funnel and is provided at its lower end with an impeller 4. This impeller consists of a horizontal disc provided on its upper side with blades of suitable shape, the clearance between the upper edges of these blades and the bell shaped rim 3 being such as to create the conditions prevailing in a centrifugal pump in which the funnel acts as suction pipe and the space between the funnel and the walls of the agitating chamber serves as the discharge pipe.

The agitating chamber has a slot 6 through which it communicates with a frothing chamber 5. The latter has an opening at its lower pointed end to which is attached a pipe 7 which establishes communication between the frothing chamber and the interior of the funnel. Another similar pipe 12 is provided for the introduction of pulp from another adjacent flotation cell.

The slot 6 is provided with a gate 8 suspended in the agitation chamber, adjacent to the wall which can be lowered and raised by means of a spindle and a handwheel 9 and thus the extent of the slot-opening can be regulated at will, the gate being only suspended adjacent to the wall, the

hydrodynamic pressure of the stream of pulp passing from the agitating to the frothing chambers will keep the gate in constant close contact with the wall thus obviating the necessity of guide grooves which easily become choked by deposits of ore particles.

One side-wall of the agitating chamber is fitted with an overflow slot 13 (Fig. 1), the height of the overflow being adjustable by a weir 13'.

This overflow slot 13 communicates with a box 14 and from this box a pipe 20 leads to the feed-funnel 12 of an adjacent agitating box. In this manner a number of cells or flotation units can be united to form a multiple cell-unit.

The impeller 4 is made of a wear-resisting material, and the bell shaped rim 3 is provided on its underside with a wear resisting and interchangeable liner; likewise the bottom and the walls of the agitating chamber 1 are protected by interchangeable wearing plates.

The horizontal disc of the impeller is provided with several circular holes and its underside is also equipped with curved blades of small height which suck air through the holes beating it into the pulp in small bubbles. The function of the above described apparatus can be explained as follows:

Considering a single cell only which is filled with ore-pulp introduced through the channel 12 into the agitating chamber and in which the impeller 4 is rotated in the proper sense and with the proper speed, it will be noted that the pulp contained in the funnel 2 is sucked off and is pumped into the space outside the funnel; assuming the slot 6 to be completely closed by the sliding gate 8 a circulation of the ore-pulp contained in the agitating chamber will take place starting from the impeller passing through the space between funnel and walls of the agitating chambers and overflowing the rim of the funnel back to the impeller. With proper speed and shape of the impeller a condition of equilibrium will be reached characterized by the funnel being constantly sucked empty of pulp.

If it be assumed that through the feed-pipe 12 a constant flow of pulp is passing into the agitating chamber, then the position of the adjustable weir 13' will determine the quantity of pulp which will be circulated in the manner set out above and which can be regulated at will within the pumping capacity of the impeller.

In the foregoing explanation of the pulp-circuit in the agitating chamber, it has been assumed that the slot 6 is completely closed by the sliding gate 8.

If however, this slot 6 be partially or completely opened then a certain quantity of pulp will pass through this slot 6 into the frothing chamber 5 and from there back through the channel 7 into the funnel 2.

The height of the pulp-level in the agitating chamber depends on the relation between the cross sectional areas of slot 6 and channel 7; if, for instance, this relation be such that through both orifices equal quantities of pulp pass per unit of time, then the pulp level in the frothing-chamber will adjust itself at such a height that h_1 (Fig. 2), equals h_2. From this it becomes clear that by varying the free cross sectional area of slot 6 by means of sliding gate 8 the pulp level in the frothing chamber can be kept constant at each height because the pulp level in the agitating chamber remains constant as set out above.

From the foregoing description it becomes evident that any pulp stream entering the agitating chamber by the channel 12 and leaving it by the overflow-weir 13' is subject during its passage to two circulations: one through the funnel and another through the frothing chamber both circulations not being dependent in some mechanical means but being solely created by hydrostatic pressure which can be kept constant by the simple means of keeping constant the speed of rotation of impeller 4 and which can moreover be easily regulated and varied.

This double circuit of the pulp as set out in the foregoing description constitutes a big advantage of the present invention over other known flotation apparatus of a similar type and for the following reasons:

(1) The aerated pulp circulates so rapidly from the agitating chamber into the frothing chamber that the air beaten into the pulp gets released only after the pulp has entered the frothing chamber and has become quiescent; the air released near the entrance of the frothing chamber rises in a multitude of line bubbles to the pulp surface and the same conditions prevail as in flotation apparatus of the pneumatic type i. e. a very rapid flotation with the production of a brittle and rather dirty bubble column. The ever newly forming froth pushes the bubble column towards the overflow end of the frothing chamber and during this travel the bubble column cleans itself by breaking down and condensing into a very clean and rather dry froth.

(2) The quantity of pulp circulating between the agitating chamber and frothing chamber can be kept very large and can be made a multiple of the pulp fed to the apparatus. This has the great advantage that the chances for all even the most reluctantly floating mineral particles to enter into the froth and to be thus recovered are many times greater than in other known apparatus of similar type.

(3) The aeration of the flotation pulp is much more intensive than in other apparatus of similar type because in addition to the air sucked in by the impeller 4 through the empty funnel 2 a large quantity of finely disseminated air is drawn into the pulp during its cascading over the rim of the funnel back into its interior, because the pulp is spread out into a thin moving sheet of extremely large surface and it is a known fact that in this way a rapid saturation of the pulp with air is accomplished.

(4) The aeration of the pulp can be regulated within wide limits by raising or lowering the overflow weir 13' whereby the pulp-overflow back into the funnel can be increased or reduced or entirely suppressed if the pulp level in the agitating chamber is lowered below the upper edge of funnel 2. Together with the aeration, also the agitation of the pulp can be regulated which is of importance for the so called conditioning of the pulp.

(5) The total quantity of pulp entering the flotation apparatus is compelled to circulate several times through the same frothing chamber whereby the maximum recovery is obtained and any "short-circuiting" is rendered impossible.

(6) The pulp level in each frothing chamber can be raised or lowered at will and in each frothing chamber independently of the pulp level in the preceding or following chamber by a simple adjustment of the sliding gate.

In this way the thickness of the froth layer can be regulated in each frothing chamber according to requirements; thus by lowering the pulp level a heavy dry and clean froth can be obtained whilst

by raising it a wet light and rather dirty froth can be produced.

(7) The funnel 2 in the agitating chamber acts as a support for the vortex set up by the rotation of the impeller and any irregular whirling of the pulps is thus avoided. In this way a considerable saving in power is effected in comparison with flotation apparatus of similar type not provided with this funnel.

(8) On account of the intensive aeration effected by the continuous cascading of the pulp through the funnel 2 it is rendered possible to lower the speed of rotation of the impeller considerably below that considered up to the present as the critical speed (500–550 meters per minute). This of course entails a further saving in power.

(9) Due to the gravity flow of the pulp through the apparatus and the complete absence of any suction-transport of the pulp, it is possible to start the apparatus after a shut-down without having previously to clean the apparatus of the settled solids.

The flotation apparatus can be modified from that set out in the foregoing description, viz.;

(*a*) Instead of the overflow-opening 13 regulated by weir 13' for the passage of the pulp from the agitating chamber to the next one, a vessel 18 (Figs. 3 and 4), can be provided in the funnel 2 alongside of and near its upper edge, which is covered by two sliding launders 21 (Fig. 4) and by shifting these launders the inlet opening of this vessel can be enlarged or reduced at will. The pulp stream entering the agitating chamber being constant, it follows that by reducing the inlet opening of vessel 18 the pulp level in the agitating chamber will rise until such a hydrostatic head is established above the upper edge of the funnel as will be required to maintain a constant flow of the pulp through the agitating chamber even with the restricted inlet opening of vessel 18. This higher hydrostatic head will also cause a heavier overflow of pulp back into the funnel and in this way the aeration of the pulp can be regulated at will.

The pulp leaving the agitating chamber by way of the vessel 18 passes from there through the channel 19 (Fig. 4) to the next agitating chamber as already set forth earlier.

(*b*) Instead of conducting the pulp from one agitating chamber through channel 12 into the bottom part of the funnel 2 of the next agitating chamber (use can be made of the hydrostatic head h_1 prevailing in one agitating chamber) to inject the pulp through a sloping and closed channel 20, Figs. 5 and 6, into the next frothing chamber, the pulp issuing from this slot will be attained.

The intensively aerated pulp passes in this way completely and rapidly through each unit cell and before leaving each unit cell it circulates several times by way of slot 6 and channel 7 through the agitating chamber.

This manner of conducting the pulp can be applied in combination with one or the other of the devices set out earlier for the outlet of the pulp from the agitating chamber.

(*c*) For the treatment of ores rich in flotable minerals or in minerals floating only reluctantly, or, when saving in floor space is aimed at, each agitating chamber can be fitted with a second frothing chamber 5' arranged symmetrically to frothing chamber 5 and slot 6' and channel 7' will establish the communication of this frothing chamber 5 with the agitating chamber.

The impeller 4 has to be adapted in this case to the higher pumping duty required and with a slightly higher power consumption the capacity of each unit can be doubled in certain cases.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. A flotation apparatus comprising a froth chamber, an agitating chamber separated from said froth chamber by a vertical wall, a rotary vertical shaft extending through said agitating chamber, an impeller mounted on the shaft adjacent the bottom of the agitating chamber, a funnel shaped vessel in the agitating chamber and coaxial with the shaft and extending upwardly from adjacent the impeller, the wall between the froth chamber and agitation chamber being provided with an opening in its upper portion and below the top of the funnel shaped vessel, and a pipe extending from the lower part of the froth chamber to the interior of the funnel shaped vessel.

2. A flotation apparatus comprising a froth chamber, an agitating chamber separated from said froth chamber by a vertical wall, a rotary vertical shaft extending through said agitating chamber, an impeller mounted on the shaft adjacent the bottom of the agitating chamber, a funnel shaped vessel in the agitating chamber and coaxial with the shaft and extending upwardly from adjacent the impeller, the wall between the froth chamber and agitation chamber being provided with a horizontal slotted opening in its upper portion and below the top of the funnel shaped vessel, and a pipe extending from the lower part of the froth chamber to the interior of the funnel shaped vessel and said vessel having a bell-shaped outward flaring rim on its lower edge, adjacent the upper edges of the impeller blades.

3. A flotation apparatus according to claim 1, in which the funnel shaped vessel has at its upper edge a diameter of at least 40 percent of the inside width of the agitating chamber, and in which the height of the said funnel shaped vessel is only a little less than that of the said agitating chamber and very close to the height of the froth-discharge lip of the said frothing chamber.

4. A flotation apparatus according to claim 2, in which the said horizontal slotted opening in the upper portion of the agitating chamber has a cross-sectional area of between one and a half and five times that of the pipe extending from the lower part of the froth chamber to the interior of the funnel shaped vessel.

5. A flotation apparatus according to claim 2, in which the said horizontal slotted opening in the upper portion of the agitating chamber is provided with a sliding gate suspended from above and movable by means of hinged levers and manual means for varying the free cross-sectional area of said horizontal slotted opening.

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