

L. D. LYONS AND C. F. HOFF.
 FLOTATION MACHINE.
 APPLICATION FILED MAY 21, 1920.

1,389,674.

Patented Sept. 6, 1921.

4 SHEETS—SHEET 1.

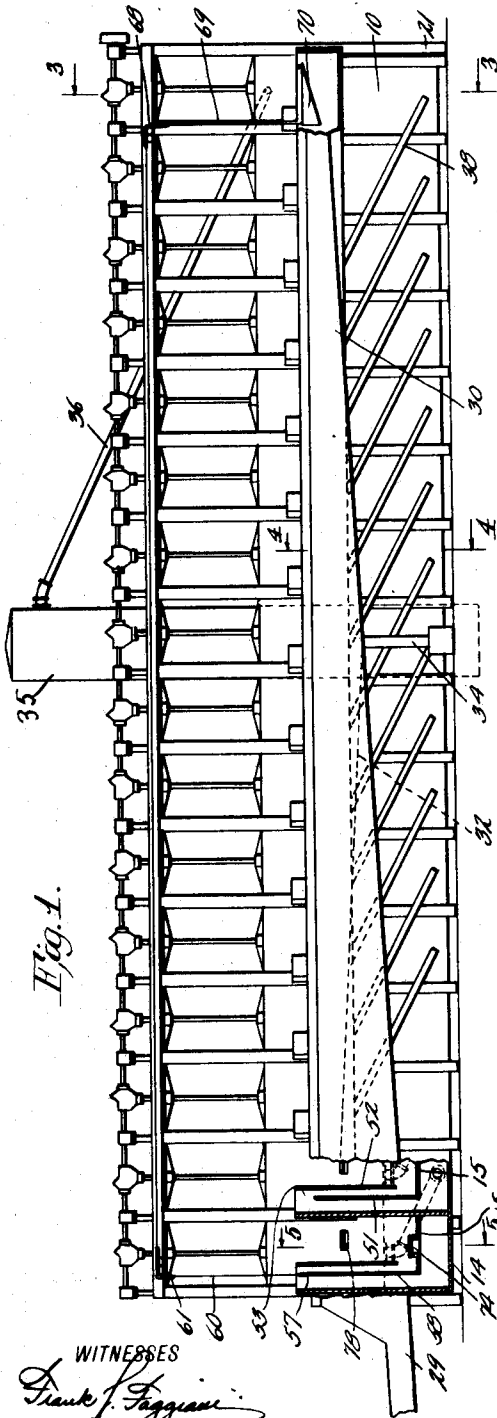


Fig. 1.

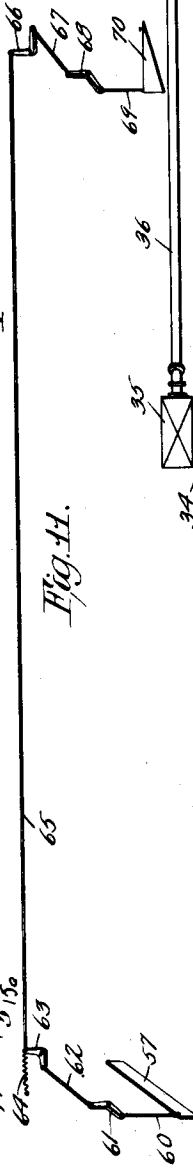


Fig. 11.

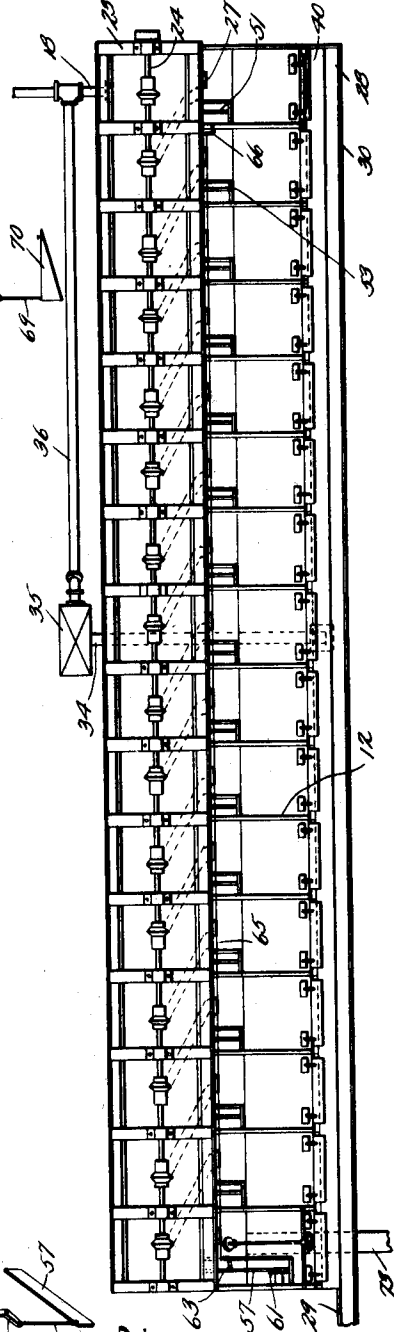


Fig. 2.

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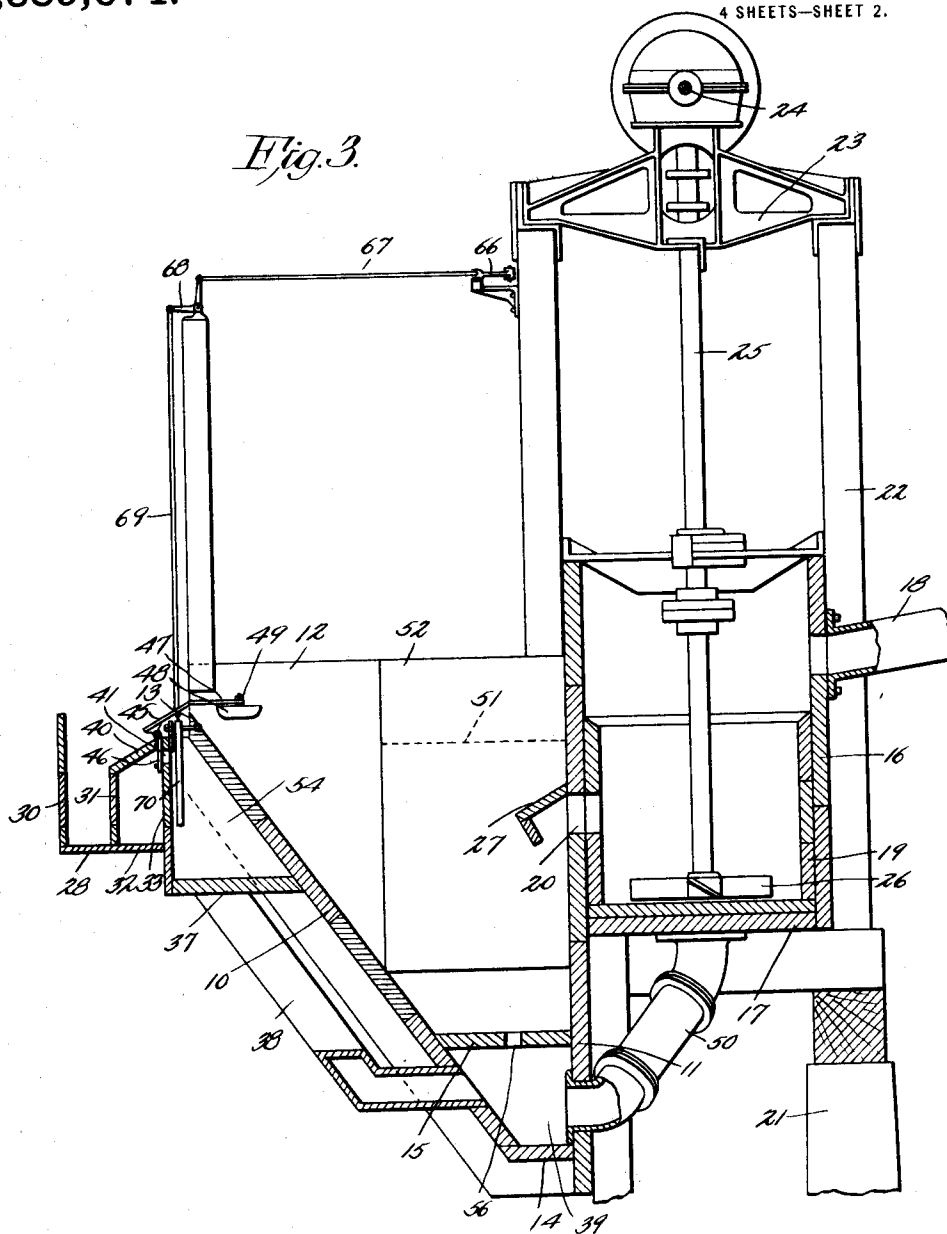
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Fig. 3.



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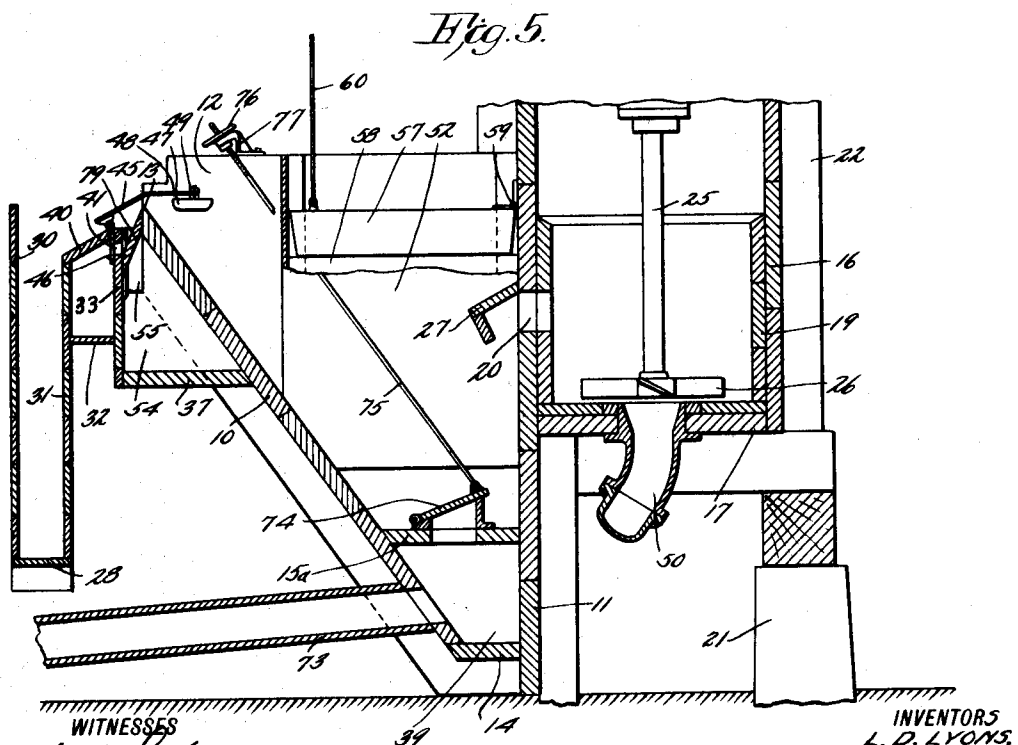
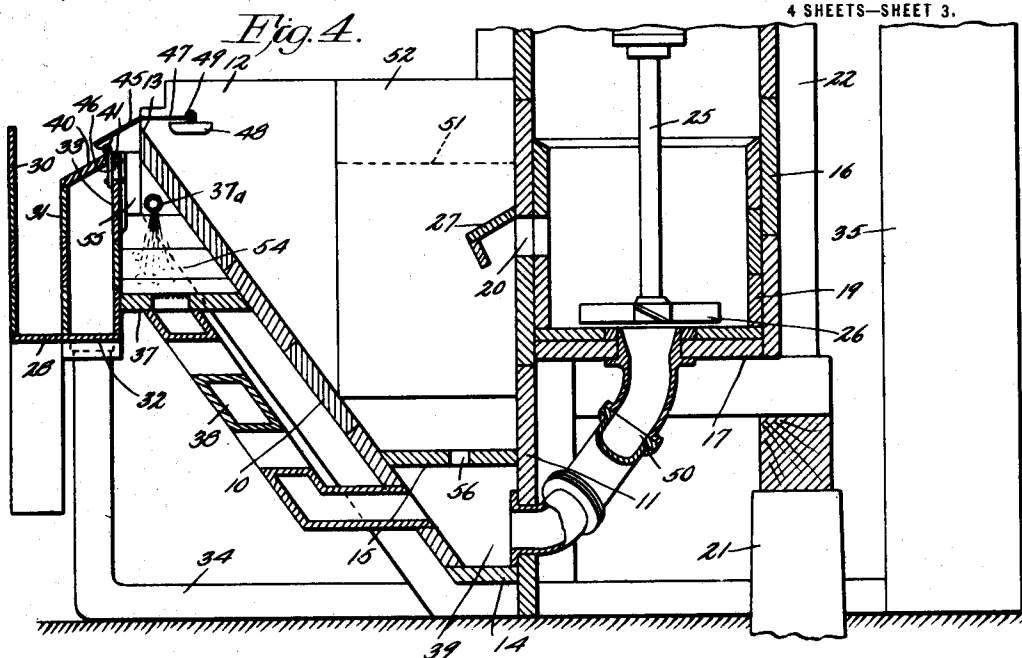
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4 SHEETS—SHEET 3.



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4 SHEETS—SHEET 4.

Fig. 6.

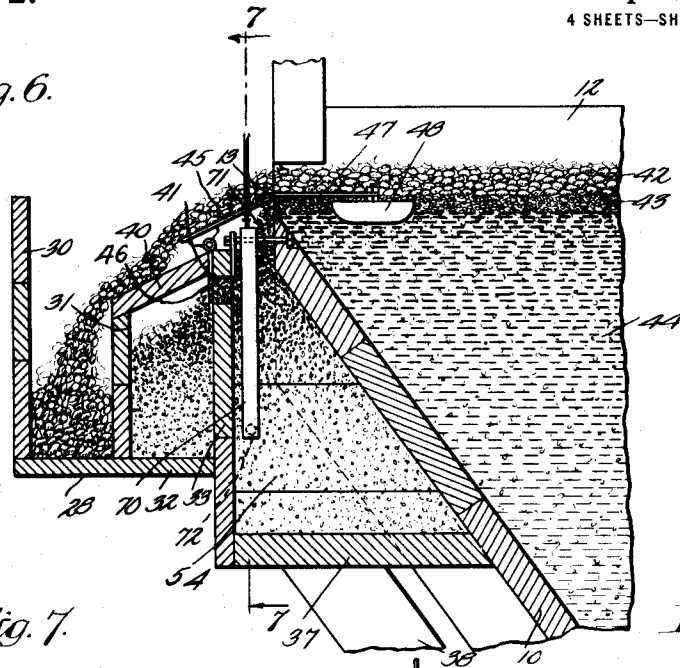


Fig. 7.

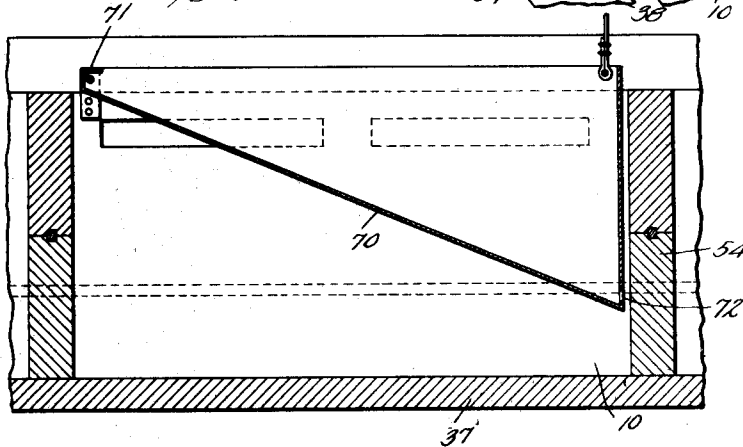


Fig. 8.

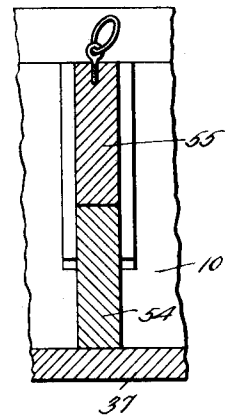


Fig. 9.

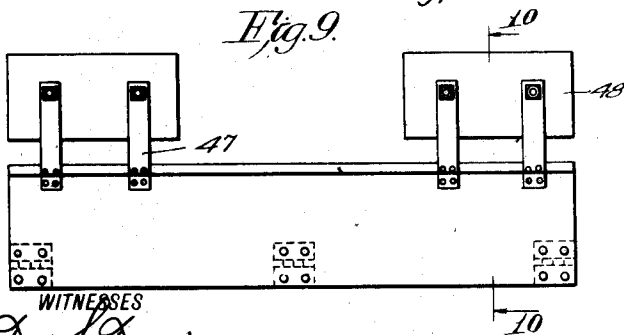
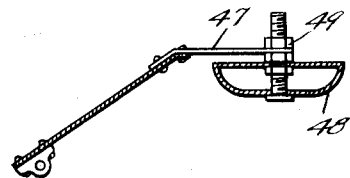


Fig. 10.



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UNITED STATES PATENT OFFICE.

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FLOTATION-MACHINE.

1,389,674.

Specification of Letters Patent.

Patented Sept. 6, 1921.

Application filed May 21, 1920. Serial No. 383,229.

To all whom it may concern:

Be it known that we, LEO DANIEL LYONS and CONRAD FRANCIS HOFF, citizens of the United States, and residents of Butte, in the county of Silver Bow and State of Montana, have invented a new and Improved Flotation-Machine, of which the following is a full, clear, and exact description.

This invention relates to means for recovering valuable minerals from their crushed ores by the flotation process, and has reference more particularly to a machine which is equipped with floating froth cutters, and an automatically controlled weir gate.

As commonly practised in the recovery of valuable minerals, the ore containing the minerals is crushed to a suitable fineness, and is introduced into a chamber where it is agitated with water to form a pulp, and a small percentage of oil and acid is added with the introduction of air during the agitation. A froth is formed, as a result, which consists in a large mass of air bubbles which rise to the surface carrying with it the valuable minerals contained in the crushed ore, and leaving behind the worthless gangue. This process is especially adapted for minerals of the sulfid type where the preferential action of the air bubbles on the valuable minerals contained in the pulp is especially marked and causes a very complete separation of said valuable minerals from the worthless gangue.

It is a known fact that in order to accomplish the very best separation, it is necessary to remove the froth containing the concentrated minerals, from the spitzkastens practically as fast as it is formed, since the air bubbles are fragile, and unless quickly removed will break and drop the valuable minerals back into the pulp. In order to accomplish this, the pulp level in the spitzkastens in the flotation machine must be maintained very close to the froth discharge level. It is difficult to maintain the pulp level in the spitzkastens at such a point where the maximum volume of froth will be skimmed off properly, and it is evident that any rise of the pulp level in the spitzkastens

above that of the normal operating pulp level will result in the "slopping" of the gangue material over with the concentrate froth into the concentrate launder. Special types of mechanical skimmers have been used to remove the froth as it is formed, but these skimmers increase the "slopping" of the gangue material, since when the skimmer paddle strikes the pulp it throws some over into the froth of the concentrate launder. Some machines are provided with a "middling" launder built parallel to the concentrate launder, and extending the full length of the machine. Aprons are provided from the lips of the spitzkastens to the outer side of the "middling launder," which extend the full width of the spitzkastens. When the machine is operating normally, the froth is skimmed off by means of the mechanical skimmer, and discharges over the apron into the concentrate launder; but when "slopping" occurs, the aprons are removed so that the concentrate froth and the gangue pulp are sent directly to the "middling" launder which leads to the feed end of the machine.

It is evident that the above provision, while it does serve to prevent gangue from "slopping" into the concentrate launder (at times only however when the operator of a machine is present to remove the necessary aprons) is a poor practice, since the concentrate froth is not sent to the concentrate launder, but is returned through the "middling" launder to the feed end of the machine to be re-worked. This greatly decreases the efficiency of the machine, since the mineral load in the machine is greatly increased by re-working so much material. Furthermore, when a concentrate is returned to the feed end of the machine, not as complete separation is obtained on re-working, since it is found that the gangue pulp tends to hinder the selective and preferential action of the air bubbles. This is especially noticed when a roughing machine is used, to be followed by a finishing machine re-working the concentrate. When a sloppy, rougher concentrate froth is made, it is possible to make this froth fairly clean and free

from gangue by excessively "banking" the cleaner machine used for the fine concentration, but to excessively "bank" (deep bed of froth hence low pulp level) will cause the tailing of the machine to have a high percentage of valuable minerals due to the bursting of the air bubbles which allows the minerals to settle into the gangue material. It often happens that when "banking" is resorted to, the operator is deceived regarding the depth of the froth in the machine, so that the loss of valuable minerals in the tailings of the machine will be excessive.

In some flotation plants, the flotation feeds vary in volume so that excess occurs at the lip of the first spitzkasten, and within a short period, unless a correction is made, there is an excessive overflow in all the spitzkastens of the machine, so that much gangue flows over with the concentrate into the concentrate launder, thus necessitating re-working of the entire concentrate. In the present machines this excessive overflow is checked by returning a less volume of "middlings" from the tailing spitzkastens to the feed end of the machine, which is usually accomplished by opening a valve in the tailing spitzkastens.

An object of this invention therefore is to provide a floating froth cutter at the lip of each spitzkasten which will always remove a definite depth of concentrate froth, regardless of the pulp level in the spitzkasten, which may vary due to variations in the volume of the pulp fed into the first spitzkasten.

Another object of this invention is to provide a means of by-passing any excessive overflow in any spitzkasten to the adjacent spitzkasten so that the pulp level will be maintained substantially constant.

Another object of this invention is to provide an automatic means for raising and lowering the weir gate in the last spitzkasten when variations in the volume of feed occur, so that the pulp level will be maintained constant.

Another object of this invention is to provide means of by-passing the pulp around one cell when same is out of order.

A further object of this invention, is to provide a flotation machine which will make a cleaner concentrate, a tailing containing a lower percentage of valuable minerals, and which will have a lower consumption of oil, acid or alkali.

A still further object of this invention is to provide a machine which will not require mechanical skimmers, and which will require a fewer number of flotation cells to produce a separation of valuable minerals from gangue.

Reference is to be had to the accompanying drawings forming a part of this speci-

cation, in which it is understood that the drawings illustrate only one form of the invention, and in which—

Figure 1 is a side elevation of the flotation machine with parts broken away to disclose the construction.

Fig. 2 is a plan view of the flotation machine.

Fig. 3 is a section through the machine on the line 3—3 of Fig. 1.

Fig. 4 is a section through the machine on the line 4—4 of Fig. 1.

Fig. 5 is a section through the machine on the lines 5—5 of Fig. 1.

Fig. 6 is a transverse sectional view on a large scale through part of one cell of the flotation machine.

Fig. 7 is a section on a large scale through a cell on the line 7—7 of Fig. 6.

Fig. 8 is a sectional view on a large scale through one of the removable overflow partitions.

Fig. 9 is a plan view on a large scale of one of the floating froth cutters.

Fig. 10 is a sectional view through the froth cutter on the line 10—10 of Fig. 9.

Fig. 11 is a diagrammatical perspective view of the system of operating levers controlling the weir gate.

Referring to the accompanying drawings by numerals, 10 indicates the front oblique wall of a spitzkasten, having a second vertical wall 11, and side walls 12. These walls of the cell form what is ordinarily called a spitzkasten, and the oblique wall 10 has a lip 13 at its upper edge, whose purpose will be hereinafter described.

A bottom 14 is formed in the spitzkasten, and a false bottom 15 is secured between the walls thereof at some distance above the bottom 14. A number of the spitzkastens are joined together in series, so that the side walls 12 of one also form the side walls for adjacent spitzkastens.

A rectangular agitating chamber 16 having a bottom 17 is secured to the side wall 11 of each spitzkasten, and an intake pipe 18 empties into said agitating chamber 16 at a point near its top. The agitating chamber 16 is lined at its bottom with a rectangular box 19, and a port 20 is provided in the wall 11 and the adjacent wall of the box 19, which opens into the spitzkasten. The agitating chamber 16 is supported by any suitable frame-work 21, and vertical standards 22 are also supported by said frame-work, said standards being provided at their upper ends with a yoke 23 which may preferably be of cast metal, and which supports a horizontal shaft 24 extending across all the spitzkastens and also supports a vertical shaft 25 in each agitating chamber 16, each shaft 25 being provided on its lower end with an impeller 26 which has blades simi-

lar to the propeller of a power driven boat. The shaft 24 may be driven by any suitable power means not shown, and is connected to each of the vertical shafts 25 by beveled gears not shown.

As the finely pulverized ore, mixed with water, a small percentage of oil and acid to form a pulp, is introduced through the pipe 18, it is agitated by the impeller 26 and mixed with air. The aerated pulp flows through the port 20 into the spitzkasten, where it rises on the false bottom 15 to the level of the lip 13. A shield, 27 extends downwardly adjacent the port 20 so as to deflect the aerated pulp from the chamber 16 to the bottom of the spitzkasten, so as to leave the froth which rises to the surface of the pulp into the spitzkasten, undisturbed. A concentrate launder 28 extends along each of the spitzkastens, adjacent the lips 13, and slopes obliquely to the delivery end of the machine, where it empties into a pipe 29 which receives the concentrate froth containing the valuable minerals. The launder 28 has an outside wall 30, and an inside wall 31, which also forms the wall of the middling launder 32, having an inside wall 33. The middling launder 32 slopes obliquely from each end of the machine to the center thereof, where it empties into a pipe 34 extending below the machine, and to the other side, where it is connected to a bucket elevator 35 delivering to a pipe 36, which is connected to the pipe 18. The inside wall 33 of the middling launder forms the outside wall of a first middling launder 37, which is substantially horizontal and has an inside wall formed by the oblique wall 10 of the spitzkasten. A plurality of oblique down-take pipes 38 are connected to the launder 37 and to a compartment 39 formed by the false bottom 15. An apron 40 extends obliquely from the wall 33 to the wall 31, and a plurality of slots 41 are formed in the wall 33 adjacent said apron so as to connect the launder 37 with the launder 32.

The froth which forms on top of the pulp in the spitzkasten is composed of concentrate froth 42, below which is a sub-froth 43 supported on the pulp 44. The concentrate froth 42 contains most of the valuable minerals (usually in the sulfid form) with very little gangue material. The top of the wall 33 is spaced apart from the lip 13 of the spitzkasten, and a cutting apron 45 is hinged on a bracket 46, which is secured to the wall 33 at the junction of the apron 40 with said wall 33.

The apron 45 has horizontal supports 47 to which are attached a plurality (preferably two in number) of metallic hollow floats 48, which are adjustably secured thereto by means of nuts 49 so that the position of the supports 47 relative to said

floats may be varied. Thus, as seen in Fig. 6 the floats 48 will be so adjusted and the supports will be so positioned that the apron 45 will act as a cutter to separate the concentrate froth from the sub-froth so that the concentrate froth will pass over the apron 45 into the concentrate launder 28, while the sub-froth 43 will pass between the walls 33 and 10 into the first middling launder 37.

The sub-froth will flow from the first middling launder 37 through the downtake pipe 38 into the compartment 39. If desired, a perforated pipe 37^a (Fig. 4) may be positioned in the launder 37 which is adapted to direct a spray of water on the sub-froth in said launder so that said sub-froth will be broken up. If the flow of the sub-froth 43 becomes too great to be handled by the down-take pipe 38 in spite of the water spray, the excess will flow through the slots 41 into the middling launder 32, which will conduct it through the pipe 34, the bucket elevator 35, the pipe 36 and the pipe 18 back into the agitating chamber 16 of the first cell. The pipe 50 connects the chamber 39 with the chamber 16, and the upper end of said pipe is positioned directly under the impeller 26 so that when said impeller is rotated in the proper direction it will draw the material from the compartment 39 into the chamber 16 where it will be further aerated.

A weir 51 is provided in each of the spitzkastens (Fig. 1) and is connected at its lower edge to the false bottom 15, while its upper edge is positioned somewhat below the lip 13 of the spitzkasten. The concentrate froth is prevented from flowing over the weir 51 by a shield 52 which is connected to the wall 12 of the spitzkasten by end-walls 53. The pulp flowing over the weir 51 is substantially free from air bubbles, since it has been taken from the bottom of the spitzkasten, and said pulp is delivered into the compartment 39 where it is combined with the products entering said compartment 39 through the down-take pipes 38.

The launder 37 is divided into compartments, one compartment for each spitzkasten, by fixed partitions 54 into which is inserted a rectangular removable partition 55 so that the overflow of sub-froth together with a small portion of gangue pulp from each lip 13 normally flows into its respective compartment formed by the partitions 54 and 55, and is transferred to the compartment 39 by each down-take pipe 38. However it sometimes happens that one down-take pipe will become clogged up, or one cell will become out of order so that, in this case the removable partition 55 is removed so that the pulp is by-passed around the cell which is out of order, to the

compartment in the launder 37 of the adjacent cell. The coarser particles contained in the pulp will settle to the false bottom 15, and will not flow over the weir 51, so that a sand hole 56 is provided in the false bottom 15, to allow these coarser particles to flow into the compartment 39, where they will combine with the other products introduced into said compartment.

It often happens in flotation plants, that the volume of pulp varies from time to time, so that an excessive overflow over the lip 13 in the first cell will soon cause a slopping over the lips 13 of the remaining cells, unless provision is made for lowering the head in the remaining cells so as to relieve the overflow conditions. For this purpose we provide a weir gate 57 at the top of a weir 58 in the last cell. This weir gate is pivoted at one end to the wall 11 of the spitzkasten, by means of a hinge 59 and its position is controlled by a rod 60 pivoted to its other end.

The rod 60 is connected to one arm of a bell crank lever 61 pivoted on the frame-work of the machine, and the other arm of said lever is connected by a rod 62 to one arm of a bell crank lever 63 also pivoted on the frame-work of the machine. A spring 64 is connected to the other arm of the bell crank lever 63 at one end, and is secured to the frame-work of the machine at the other end, so that normally the weir gate 57 is in its lowermost position. In order to actuate the bell crank lever 63, a cable or rod 65 is connected to this last mentioned arm, and extends to the feed end of the machine, where it is connected to one arm of a bell crank lever 66, pivoted to the machine. A rod 67 connects the other arm of the bell crank lever 66 to one arm of the bell crank lever 68, and the other arm of the lever 68 is connected by a rod 69 to a triangular shaped box 70 pivotally mounted by means of a pin 71 to the walls 10 and 33 of the first cell, so as to be positioned approximately in the path of the sub-froth and a small portion of gangue pulp which flows downwardly into the launder 37.

This triangular shaped box 70 is open at the top, and is provided at its lowermost corner with a port 72. This port 72 has a definite size, so that the sub-froth and a small portion of the gangue pulp flowing into said box 70 will drain out at a predetermined rate of speed. However, when the flow of sub-froth and gangue pulp becomes excessive, the box 70 will fill with material since the port 72 will not then be sufficient to drain the box, so that said box will move about its pivot 71 thus actuating the system of levers and links, thus causing the weir gate 57 to be raised. When the weir gate 57 is thus raised a portion of the

pulp in the last cell will flow out under the gate so as to lower the head in the last cell, thus causing the head to lower in all the other cells so as to relieve the overflow conditions.

When the pulp thus flows out under the weir gate it flows downwardly into the compartment 39 of the last cell, and then flows out of said compartment through a tail race 73, which conducts away the useless gangue material. A false bottom 15^a in the last cell is provided with a pivotally mounted valve 74 to which is connected a control rod 75, and the opening in said valve may be accurately controlled by means of an adjusting wheel 76 threaded to receive the end of the rod 75, and mounted on a bracket 77 secured to the machine. The flow of the gangue material past the valve 74 may thus be manually controlled so that proper operation of the machine is obtained.

Extra large slots 78 are provided in the wall 33 of the last two cells so that a relatively large portion of the middling overflow from the tailing spitzkasten is returned to the feed end of the machine through the middling launder 32. The first middling launder in the last two cells may be cut out by inserting an oblique gate 79 between the wall 10 and the wall 33 so that the middling flows directly into the middling launder and is returned to the feed end of the machine.

In operation, the pulp which consists of crushed ore, water, and small percentages of oil and acid, is introduced into the agitating chamber 16 on the first cell through the pipe 18, and is thoroughly aerated and agitated by the impeller 26. The aerated pulp flows out through the port 20 into the spitzkasten and is deflected downwardly toward the false bottom 15 of said spitzkasten by the shield 27. The air bubbles containing the valuable minerals rise to the surface, and form a concentrate froth 42, which is supported by the sub-froth 43, in turn supported by the pulp 44. The coarser particles in the pulp, settle to the bottom of the spitzkasten and flow through the hole 56 into the false bottom 15, into the compartment 39. The major part of the pulp admitted to the spitzkastens overflows the weir 51, and is combined with the other material in the compartment 39. The froth, sub-froth and a small portion of the gangue pulp overflow the lip 13 of the spitzkasten where the apron cutter 45 cuts the concentrate froth from the sub-froth so that the former flows into the concentrate launder 28, while the latter flows into the first middling launder 37. This apron cutter 45 is maintained in a definite position relative to the froths 42 and 43 by the float 48 which floats on the surface of the pulp 44 so that

a uniform cutting of the concentrate froth from the sub-froth is obtained at all times, regardless of the pulp level in the spitzkasten.

5 The sub-froth flowing into the first middling launder 37 passes through the down-take pipe 38 into the compartment 39, where it joins the other products from the sand hole 56 and the weir 51. The products com-
10 bined in the compartment 39 are drawn up through the pipe 50 into the agitating chamber 16 of the next cell by the impeller in that compartment, where it is again aerated and goes through the cycle of
15 operations described in the first cell. The worthless gangue material which collects in the compartment 39 of the last cell, flows out of the machine through the tail race 73, while the concentrate froth flows out of the
20 concentrate launder 28 through the pipe 29, after which it is treated further to recover the valuable minerals.

If the pulp fed to the first agitating chamber varies in volume from time to time,
25 and an excessive overflow occurs at the lip 13 of the first spitzkasten, the overflow fills up the triangular shaped tank 70 drained by the port 72, which actuates the system of levers and links illustrated in Fig. 11, so
30 that the weir gate 57 in the last cell is raised, thus causing pulp to flow out of the last cell under said weir gate, where it goes with the worthless gangue to the tail race 73. If the overflow in the first middling launder 37 is
35 so great that it cannot be handled by the down-take pipe 38, the excess overflow flows through the slot 41 into the middling launder 32, which conducts the overflow through the pipe 34, the elevator 35, the pipe 36 and
40 the pipe 18, back into the agitating chamber of the first cell of the machine. In case this method of handling the overflow is not sufficient, the excess flows over the removable partition 55 into the first middling
45 launder compartment of the next cell. If any of the down-take pipes or other part of the cell become out of order or plugged up, the removable partition 55 may be removed so that the excess pulp is by-passed
50 around the cell which is out of order to the next cell.

A flotation machine is thus provided in which a definite depth of concentrate froth is removed at all times regardless of the
55 pulp level in the spitzkasten, which may vary with variations in the volume of the pulp fed into the first spitzkasten. The machine is also provided with means for automatically equalizing and regulating the
60 flow of pulp through the several cells so that the pulp level will be maintained substantially constant. If one cell becomes out of order, the pulp may be easily by-passed around this cell to the next cell in the se-
65 ries. All mechanically operated skimmers

have been eliminated from the machine and a fewer number of flotation cells are necessary to produce a given separation of minerals from the gangue. It may be desirable to use a mechanical type of slow revolving
70 skimmers in some cases which will be positioned near the center of the spitzkastens of the machine, said skimmers being adapted to further increase the discharge of concentrate froth over the froth cutter. 75
The machine described and illustrated will make a cleaner concentrate, a tailing containing a lower percentage of valuable minerals, and will have a lower consumption of oil, acid or alkali. 80

We would state in conclusion that while the illustrated example constitutes a practical embodiment of our invention, we do not limit ourselves precisely to the details
herein illustrated, since manifestly the same
85 can be considerably varied without departing from the spirit of the invention, as defined in the appended claims.

Having thus described our invention we claim as new and desire to secure by Letters Patent:

1. In a flotation machine provided with a container, having an overflow lip, and a movably and automatically operated member associated with said container for uni-
95 formly separating the concentrate froth from the sub-froth, as said froths flow over said lip regardless of the level of the pulp in said container.

2. A flotation machine provided with a
100 container having an overflow lip, floating cutting means associated with said container adapted to separate a uniform depth of concentrate froth from the sub-froth, as said
105 froths flow over said lip, regardless of the level of the pulp in said container.

3. In a flotation machine, a plurality of containers arranged in series, and means associated with the first said containers adapted to release a quantity of pulp from the
110 last of said containers when an excessive supply of pulp is introduced into the first of said containers, so that the pulp level in said container is maintained substantially
115 constant.

4. In a flotation machine, a plurality of containers arranged in series, a pivotally mounted weir gate associated with the last container in said series, and means associated with the first container for moving
120 said weir gate when an excessive quantity of pulp is introduced into the first container, so that the pulp level in said containers is maintained substantially constant.

5. A device, as described in claim 4, characterized by a pivotally mounted box associated with the first of said containers, said box being so positioned as to receive an excessive flow of material introduced into said
125 first container, there being a port formed
130

adjacent the bottom of said box adapted to allow the pulp to drain from said box during a normal flow of material but to cause said box to overflow during an excessive flow of pulp into said container so that said box will be moved about its pivot, and connecting means between said box and said weir gate adapted to actuate said gate when said box is moved about its pivot, so that the pulp level in the containers is maintained substantially constant.

6. In a flotation machine, a plurality of containers arranged in series, each container being provided with an overflow lip, means associated with each container adapted to aerate and agitate the pulp, and introduce said aerated pulp into said containers, a concentrate launder positioned longitudinally of said containers adapted to receive the concentrate froth delivered from each container, a first middling launder adapted to receive the sub-froth and a portion of gangue pulp, delivered from the lip of said container, a middling launder positioned longitudinally of said container adapted to receive an overflow of sub-froth from the first middling launders, a weir associated with each container adapted to allow the overflow of pulp therefrom, and means for combining said pulp overflowing said weir and said sub-froth overflowing the lip of said containers and transferring said pulp and said sub-froth from one container to an adjacent container in the said series.

7. A device as described in claim 6, characterized by means for separating a uniform depth of said concentrate froth from said sub-froth flowing over the lip of each container, regardless of the level of the pulp in each container.

8. A device as described in claim 6, characterized by means for by-passing the pulp around a container in said series, when said container is out of order.

9. A device as described in claim 6, char-

acterized by a movable weir gate, associated with the last container in said series, and means associated with the first container in said series adapted to actuate the said weir gate when an excessive quantity of pulp is introduced into the first container of said series, so that the pulp level in said container will be maintained substantially constant.

10. In a flotation machine, a container provided with a lip, means for introducing an aerated and agitated pulp into said container so that a concentrate froth and a sub-froth are formed on the surface of said pulp, means for causing the pulp to flow from said container, a cutter apron pivotally associated with said container, and a floating member associated with said cutter apron adapted to float on the surface of said pulp, and maintain one edge of said cutter apron above said pulp surface in such a position that a uniform depth of concentrate froth will be separated from the sub-froth regardless of the level of pulp in said container.

11. A device as described in claim 10, characterized by means for combining the pulp flowing from said containers with the sub-froth flowing over the lip of said containers and transferring said combined pulp and froth to an adjacent container.

12. A device as described in claim 10, characterized by a false bottom positioned in said containers, means for combining said sub-froth with said pulp, and means for transferring said combined pulp and sub-froth to adjacent containers.

13. In a flotation machine, a container having an overflow edge, and a pivoted and automatically controlled member at said edge for separating the concentrate froth from the sub-froth as they flow over said edge.

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