J. F. MYERS.

FLOTATION APPARATUS.

APPLICATION FILED OCT. 22, 1918.

1,323,373.

Patented Dec. 2, 1919.

2 SHEETS—SHEET 1.

Fig. 1.

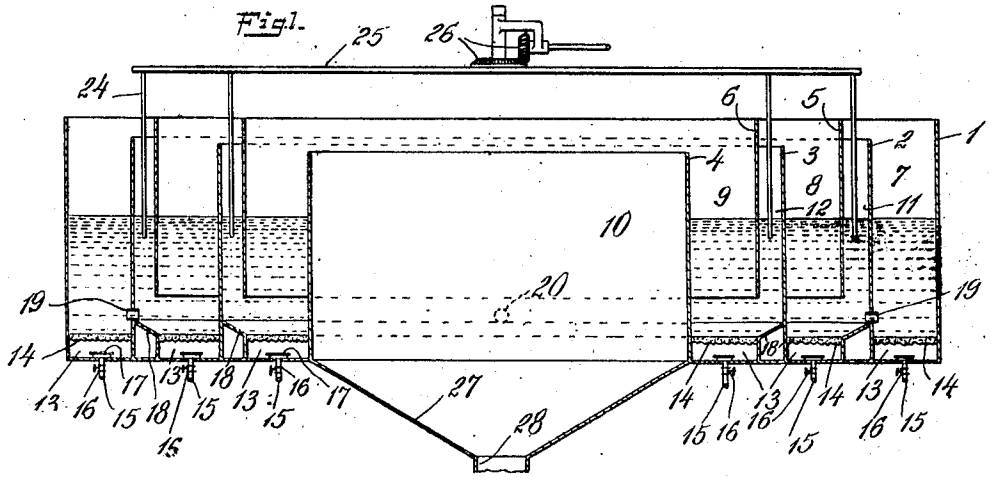


Fig. 2.

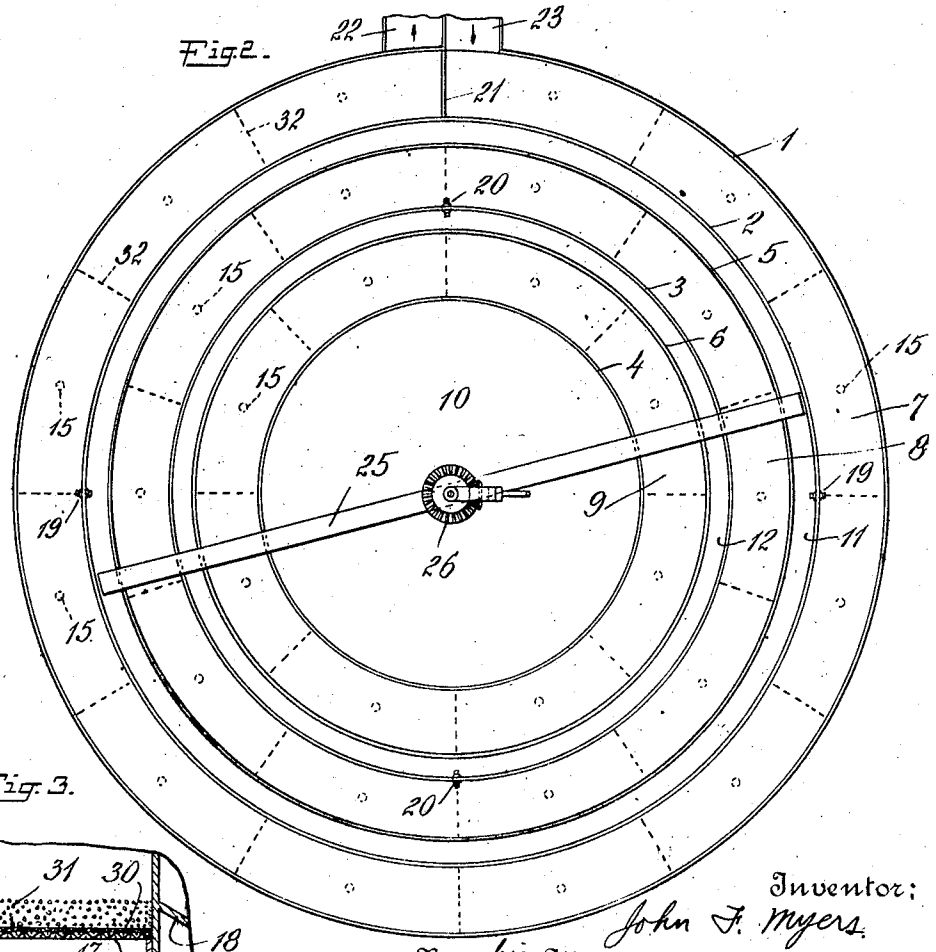
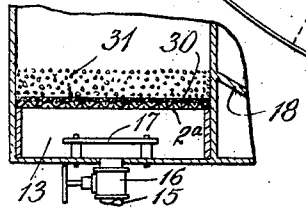


Fig. 3.



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Fig. 4.

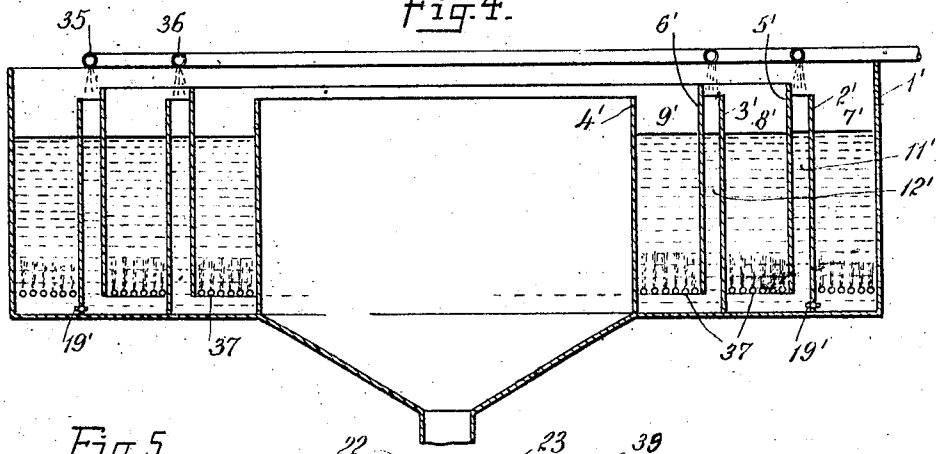


Fig. 5.

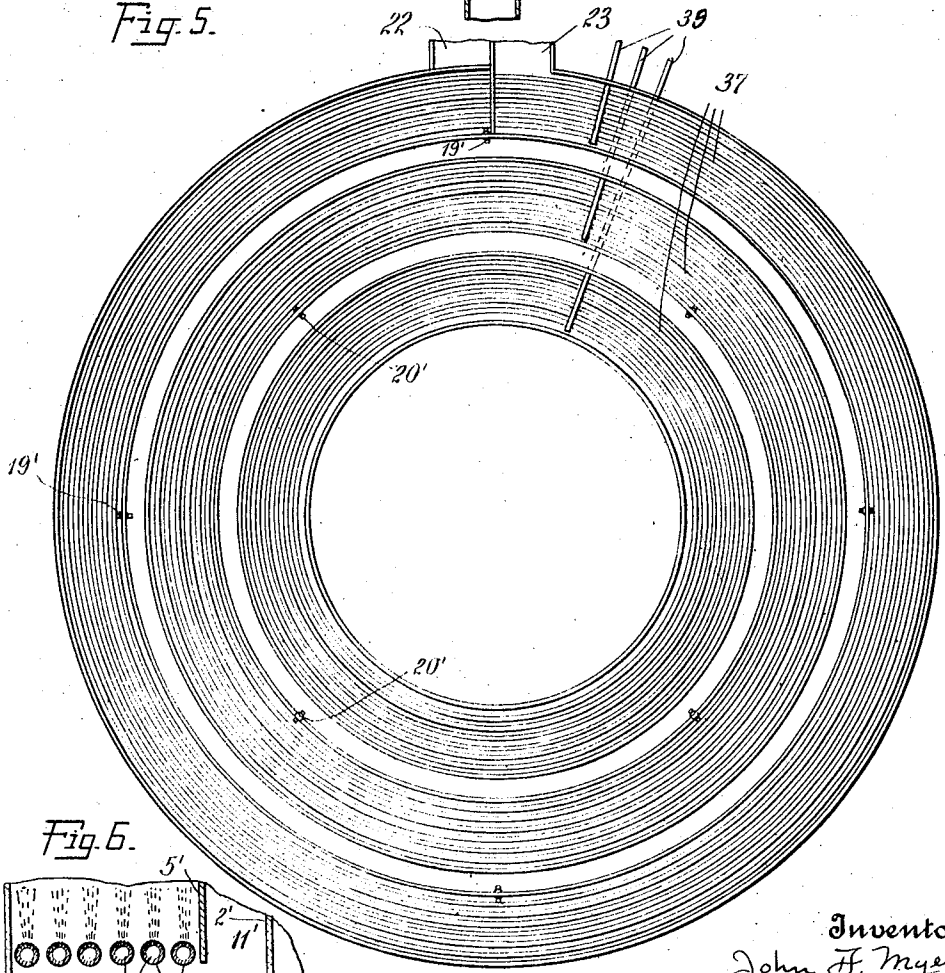


Fig. 6.

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UNITED STATES PATENT OFFICE.

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FLOTATION APPARATUS.

1,323,373. Specification of Letters Patent. Patented Dec. 2, 1919.

Application filed October 22, 1918. Serial No. 259,200.

To all whom it may concern:

Be it known that I, JOHN F. MYERS, a citizen of the United States, residing at Canyon City, in the county of Fremont, State of Colorado, have invented certain new and useful Improvements in Flotation Apparatus; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to an apparatus for the concentration of minerals in accordance with the so-called flotation process.

The apparatus of the present invention is made up of a plurality of compartments or cells of annular or other contour surrounding each other and so arranged with respect to each other that the froth from one cell is fed to the next, and the tailings are fed from one cell to another in counter current to the flow of the froth.

The invention will be further described in connection with the embodiment thereof, illustrated in the accompanying drawings, in which:

Figure 1 shows in central, vertical section an apparatus embodying the invention, the illustration being, in part, of a conventional character; Fig. 2 is a plan of the same apparatus; Fig. 3 is an enlarged detail showing one form of construction of the porous bottom of the apparatus; Fig. 4 shows in central, vertical section, another form of apparatus embodying the invention; Fig. 5 is a plan of the apparatus of Fig. 4; and Fig. 6 is an enlarged detail showing the form of air bottom used in the apparatus of Fig. 4.

The apparatus illustrated in Figs. 1, 2 and 3 is made up of the four concentric walls 1, 2, 3 and 4, suitably connected at their lower ends. Depending within the compartments formed by these concentric walls are concentric walls 5 and 6, which extend nearly to the bottom of the compartments, but are spaced away therefrom. These depending walls may be supported in any suitable manner (not shown). The arrangement of the concentric walls is such that there are formed three annular flotation compartments 7, 8 and 9, and two annular inlet compartments 11 and 12. Inside the central annular wall 4 is the central chamber or compartment 10, having a sloping bottom 27 leading to a suitable discharge outlet 28.

In the bottom of the apparatus there is provided a series of air chambers 13 covered by a porous bottom 14 of any suitable construction and supplied by air through air supply pipes 15, each of which has an independent control valve 16 and each of which is protected by a baffle plate or distributer 17. These air chambers do not extend over the entire bottom of the apparatus, but are localized beneath the compartments 7, 8 and 9, so that the air introduced therethrough acts in these respective compartments and does not act in the overflow or feed compartments 11 and 12. Baffles or bottom plates 18 are provided at the bottom of the compartments 11 and 12 to form the bottom thereof and to aid in directing the flow of the pulp from the compartments 11 and 12 to the adjoining inner compartments.

The concentric walls 2 and 3 are provided near the lower end thereof with check valves 19 and 20, through which communication is afforded for circulation of the ore pulp from both of the inner compartments 8 and 9 to the next adjacent compartments 7 and 8, respectively. The check valves are so constructed so as to permit the pulp to flow from the inner compartment to the adjacent outer compartment, and so as to prevent any flow of pulp therethrough in the opposite direction. Thus, the check valves 19, of which there may be a suitable number, permit the pulp to travel from compartment 8 to compartment 7, but not from compartment 7 to compartment 8. Likewise the check valves 20 are constructed so that the pulp can go from compartment 9 to compartment 8, but not from compartment 8 to compartment 9. By this arrangement, the ore pulp can flow through the various compartments in only one direction, to wit, from the innermost compartment toward the outermost compartment.

A partition 21 is provided in the outer compartment 7. An outlet 22 is arranged on one side of this partition and communicates with the compartment 7 below the normal liquid level therein. An inlet 23 is arranged on the other side of the partition 21.

Stirrer rods 24 carried by arms 25 are provided for assisting in breaking up the froth

in the compartments 11 and 12, if this is necessary or desirable, these stirrers being rotated slowly in any suitable manner, as by means of the bevel gears 26. The stirrers and driving means therefor may be supported in any suitable manner (not shown).

As above noted, the perforated bottom 14 may be of any suitable construction, such as is commonly employed in flotation apparatus of the character where air is introduced through a porous bottom into the flotation cell. One suitable form of porous bottom is shown in the enlarged view of Fig. 3, this bottom being made up of a coarse screen cloth 29 with a layer of finer cloth supported thereon and with metallic shot or spherules supported by the upper cloth of sufficient fineness and depth to effect a uniform distribution of the entering air. The metallic spherules may, for example, vary in size from 0.08 inches to 0.03 inches diameter, or from about No. 9 to fine dust, American standard. The depth of the layer of spherules or shot may vary, for example, from one-half inch to one or two inches.

When the apparatus is in normal operation, the outer or first flotation compartment or cell 7 is the rougher cell, while the inner flotation compartments or cells 8 and 9 are the cleaner and re-cleaner cells, respectively. The normal operating condition of the apparatus may be initiated in any suitable manner, as, for example, by feeding the ore pulp to all three cells or compartments and operating the apparatus, as hereinafter described, until the intermediate and inner cells 8 and 9 are in proper condition to operate as cleaner and re-cleaner cells, respectively.

After the apparatus is in normal operation, the ore pulp is fed to the first cell 7 of the series through the inlet 23. The level of the pulp can be determined in any suitable manner, as by means of a float-control inlet (not shown). Air is introduced through the pipes 15 to the air compartments 13 and is discharged through the porous bottom 14 into the respective compartments 7, 8 and 9 which thus form flotation cells or compartments. The froth formed in the compartments 7, 8 and 9 overflows the inner annular walls 2, 3 and 4, which terminate at progressively lower levels, so that the froth is re-treated in the inner compartments, and finally discharged into the central outlet compartment 10.

The froth formed in the outer or rougher flotation cell 7 overflows into the annular chamber 11. This overflow froth from the rougher cell 7 then forms the feed of the second or middle flotation cell 8, which thus acts as a cleaner cell, and the froth therefrom overflows in a similar manner into the annular chamber 11, from whence it is fed into the inner cell or compartment 9, which serves as a re-cleaner cell. The froth from the re-cleaner cell 9 overflows into the central compartment 10 and is conducted therefrom to any suitable place for further treatment or storage. The stirrers 24, when used, serve to break up the overflowing froth, in case such breaking up is necessary.

The check valves 19 and 20 permit the tailings to flow outwardly from the inner compartments to the adjacent outer compartment, in which they are themselves re-treated. The tailings discharged into the outer compartment 7 are therein re-treated and the tailings from this compartment finally escape therefrom through the outlet 22. When the apparatus is in normal operation, the only feed of the inner flotation compartment is that of the overflow froth from the next outer flotation compartment. The froth formed in the outer cell is re-treated in the next inner cell, and the froth of the latter is in turn re-treated in the inner cell, while the tailings from the inner cells flow outwardly and are similarly re-treated.

The arrangement of the inlet 23 and of the outlet 22 is such that the entering pulp is distributed around the outer compartment 7, and so that the tailings escape from this compartment through the outlet 22, which is arranged on the opposite side of the partition 21 from the inlet 23. The ore pulp thus flows around the outer annular compartment or flotation cell from the inlet 23 to the outlet 22. While the pulp is thus flowing through this outer annular compartment it is continuously and everywhere throughout the compartment subjected to a flotation treatment. The rough froth overflowing from this outer flotation cell is re-treated in the intermediate or cleaner cell 8, and the tailings from this second flotation treatment escape from the cleaner cell through the check valves 19 into the outer cell, while the overflowing froth is subjected to a further flotation treatment in the inner cell 9. The tailings from this last flotation treatment escape through the check valves 20 into the intermediate flotation cell 8, where they again undergo the flotation treatment. The overflow froth is thus progressively retreated in each succeeding inner flotation cell. Similarly, the tailings which escape from the inner flotation cells to the next adjacent outer cell are retreated in each of the latter.

It will thus be seen that the apparatus operates on the counter current principle with the tailings from the inner cells flowing by gravity into the outer cells and being again retreated therein while the froth from the outer cells overflows into the next inner cells and is there again retreated.

The operation as a whole accordingly involves a progressive enrichment of the froth formed, and a progressive impoverishment of the ore pulp in values. The arrangement is, moreover, such that a minimum of power is required for the operation of the apparatus inasmuch as the transfer of the froth from one part of the apparatus to another takes place by overflow, and inasmuch as the tailings flow by gravity in the reverse direction. Centrifugal pumps or other apparatus for conveying the froth or concentrate and the tailings from one flotation machine to another are unnecesary.

The compressed air supplied to the apparatus may be obtained in any convenient manner, such as is common in the art, and it may be introduced under a regulated pressure so that the operation of the apparatus can be thereby controlled. Each of the air pipes is provided with a regulating valve so that each of the compartments 13 can be independently regulated. For convenience of distribution and regulation each of the flotation cells 7, 8 and 9 is provided with a large number of independent air compartments 13 separated from each other by partitions indicated by dotted lines 32 in Fig. 2. Each of the air compartments 13 may also be provided with draw-off openings or pipes (not shown) for permitting the draining of these respective compartments in case of necessity therefor.

Where the apparatus is made with a larger or smaller number of flotation cells or compartments, the apparatus will nevertheless operate in the same manner, with progressive enrichment of the concentrate and progressive impoverishment of the ore pulp. So also if the apparatus is made anything other than circular in form and with concentric cells or compartments, it will nevertheless retain its characteristic mode of operation and simplicity of structure. The circular and concentric arrangement of the flotation cells is, however, of particular advantage, since by such an arrangement the cells may be conveniently designed of progressively decreasing size corresponding to the progressively decreasing amount of ore pulp which each succeeding cell must handle. Thus the circular and concentric arrangement of the flotation cells provides a very compact structure in which each inner cell is of progressively smaller capacity than the next adjacent outer cell.

In operating the apparatus, the quantity of material overflowing the wall 2 is larger than that overflowing the wall 3, and hence there is always a tendency for the liquid level in compartment 8 to be higher than the liquid level in compartment 7, and this difference in hydraulic head keeps the check valves 19 open under normal operating conditions, thereby permitting the ore pulp or tailings to flow through the check valves 19 from compartment 8 into compartment 7. Similarly, the quantity of material overflowing the wall 3 is larger than that overflowing the wall 4, whereby there is established between the compartments 9 and 8 a difference in hydraulic head which, under normal operating conditions, maintains the check valves 20 open and produces a flow of ore pulp or tailings from compartment 9 into compartment 8 through these open check valves. In case no froth is being discharged from compartment 7 for a short period of time, and the liquid level in compartment 8 becomes the same as in compartment 7, the check valves 19 will close, thus keeping the low grade material in compartment 7 from getting into the cleaner cell or compartment 8. And again, in case no froth is overflowing the wall 2 into the compartment 8 for a short period of time, while froth continues to flow over the wall 3 into compartment 9, causing the liquid level in compartment 8 to become lower than in compartment 7, no flow of pulp can take place from compartment 7 into compartment 8, because, under such conditions, the check valves 19 remain closed. The same principles obviously apply to the two compartments 8 and 9. It will furthermore be evident that the arrangement of check valves facilitates starting up the apparatus, when empty.

In Figs. 4, 5 and 6 of the drawings, there is shown a slightly modified form of apparatus embodying the invention. The apparatus comprises three concentric compartments 7′, 8′ and 9′, having froth overflow walls 2′, 3′ and 4′ respectively. The walls 2′, 3′ and 4′ are of substantially the same height, and not progressively lower, as in the modification of Fig. 1. The depending concentric walls 5′ and 6′ are preferably higher than the walls 2′, 3′ and 4′, so as to direct the overflow froth into the froth inlet compartments 11′ and 12′, and so as to prevent any backward flow of the froth. The walls 2′ and 3′ have near their bottoms check valves 19′ and 20′, of the same character as in the apparatus of Fig. 1.

Circular water spray pipes 35 and 36 are arranged above the froth inlet compartments 11′ and 12′, respectively. The spray from these pipes serves to break up the froth. These pipes, furthermore, provide a convenient means for adding water, where, in the operation of the apparatus, it is desirable to increase the dilution of the cleaner and recleaner cells.

The porous bottom of the apparatus of Figs. 4 and 5 is shown in detail in Fig. 6. This porous bottom is in the form of an air grate composed of pipes 37 drilled with holes to provide air exit apertures. Each pipe 37 is covered with a layer 38 of canvas,

or equivalent material. The pipes 37 are spaced apart to permit the passage of material through the grate. The air grates are so positioned that the air coming from the pipes into the flotation cells has no opportunity of passing into the froth inlet compartments 11′ and 12′. In an air grate of this type which I have successfully operated, the pipes 37 were half-inch pipes suitably drilled with holes and covered with canvas. The pipes were spaced 1/4 inch apart. In the drawings I have shown the pipes 37 as circular and extending completely around the flotation cells, but it will of course be understood that the pipes may be sector-shaped and arranged in sections, and that more than one air inlet 39 may be provided.

The operation of the apparatus of Figs. 4, 5 and 6 is substantially the same as described in connection with the apparatus of Figs. 1, 2 and 3. It is, accordingly, believed that no further explanation of the modified construction is necessary, and that its operation will be clear to those skilled in the art.

From the foregoing description it will be seen that in the apparatus of the invention a plurality of flotation cells are arranged in series. The first cell of the series is the rougher cell from which the overflow froth passes by gravity to the next adjacent cell in the series. The last cell of the series is the cleaner cell from which the overflow froth is collected and the tailings passed by gravity to the next preceding cell in the series. In the intermediate cells of the series the overflow froth and tailings flow in counter-current, the overflow froth passing by gravity toward the last cell in the series and the tailings passing by gravity toward the first cell in the series. Thus, in the apparatus of the invention the raw mineral pulp to be treated is fed to the first cell of the series and is subjected to the first flotation treatment in this cell.

I claim:

1. A flotation apparatus comprising a plurality of flotation cells surrounding one another, each of said cells being provided with a porous bottom for the introduction of air, said cells being arranged so that the froth overflows from one cell to another and so that the tailings escape from one cell to another in the reverse direction to the flow of the froth.

2. A flotation apparatus comprising a plurality of annular flotation cells concentrically arranged, each of said cells having a porous bottom for the introduction of air, said cells being arranged so as to direct the froth overflow of each cell into the next adjacent inner cell and so that the tailings of each cell escape into the next adjacent outer cell.

3. A flotation apparatus comprising a plurality of annular flotation cells concentrically arranged, each of said cells being provided with a porous bottom for the introduction of air, intermediate annular compartments arranged between adjacent cells and adapted to receive the overflow froth from the adjacent outer cell and to feed such froth into the adjacent inner cell, and means permitting the escape of tailings from each inner cell to the adjacent outer cell.

4. A flotation apparatus comprising a plurality of annular flotation cells concentrically arranged, each of said cells having a porous bottom for the introduction of air, the inner walls of said cells being progressively lower so as to permit the progressive overflow of froth from the outer-most cell to the inner-most cell, and means for directing the overflow froth of each cell to the next adjacent inner cell.

5. A flotation apparatus comprising a plurality of flotation cells surrounding one another, each of said cells being provided with a porous bottom for the introduction of air, the inner wall of each of said cells being lower than the outer wall thereof and also lower than the inner wall of the next adjacent outer cell, means for directing the froth overflow of each cell into the next adjacent inner cell, and means for permitting the escape of tailings from each inner cell to the next adjacent outer cell.

6. A flotation apparatus comprising a plurality of concentrically arranged annular compartments, each of said compartments having a porous bottom arranged for the introduction of air, a circular wall depending into each of the inner of said compartments and arranged to divide such compartments into a froth inlet compartment and a flotation compartment, the inner walls of said annular compartments being progressively lower so as to direct the overflow froth from each flotation compartment to the adjacent froth inlet compartment, and means for permitting the escape of tailings from each of said annular compartments to the next adjacent outer annular compartment.

7. A flotation apparatus comprising a series of flotation cells, each of said cells being provided with a porous bottom for the introduction of air, means for feeding the raw ore pulp to be treated to the first cell in said series, means for withdrawing the exhaust tailings of said apparatus from said last mentioned cell, means for directing the overflow froth of each cell to an adjacent cell in said series, and means for permitting the escape from each cell of tailings in the reverse direction to the flow of the froth.

8. A flotation apparatus comprising a plurality of flotation cells, said cells being

operatively arranged in series so that the froth overflows from one cell to another and so that the tailings escape from one cell to another in the reverse direction to the flow of the froth, and means for feeding the raw ore pulp to be treated and for withdrawing the exhaust tailings of said apparatus from the first cell in said series.

9. A flotation apparatus comprising a plurality of flotation cells, said cells being operatively arranged in series, means whereby each cell intermediate the first and last cell in the series subjects the overflow froth of the preceding cell in the series together with the tailings from the succeeding cell in the series to a flotation treatment, and means for feeding the raw ore pulp to be treated and for withdrawing the exhaust tailings of said apparatus from the first cell in said series.

10. A flotation apparatus comprising a plurality of flotation cells, said cells being operatively arranged in series, and means for feeding by gravity to each cell intermediate the first and last cell in said series the overflow froth from the next preceding cell in the series and the tailings from the next succeeding cell in the series.

11. A flotation apparatus comprising a plurality of flotation cells operatively arranged in series, means for feeding the overflow froth of each cell, except the last cell in the series, to the next succeeding cell in the series, means for permitting the escape by gravity of the tailings of each cell, except the first cell in the series, to the next preceding cell in the series, means for collecting the overflow froth of the last cell in the series, and means for feeding the raw ore pulp to be treated and for withdrawing the exhaust tailings of said apparatus from the first cell in said series.

12. A flotation apparatus comprising a plurality of flotation cells operatively arranged in series, means for feeding by gravity the overflow froth of each cell in said series, except the last cell thereof, to the next succeeding cell in the series, means for permitting the tailings to escape by gravity from each cell in said series, except the first cell thereof, to the next preceding cell in the series, and means for subjecting the overflow froth and tailings in each cell to a flotation treatment.

13. A flotation apparatus comprising a plurality of fletation cells operatively arranged in series, means for subjecting to a flotation treatment in each cell of said series, intermediate the first and last cell thereof, the overflow froth from the next preceding cell in the series and the tailings from the next succeeding cell in the series, and means for feeding the raw ore pulp to be treated and for withdrawing the exhaust tailings of said apparatus from the first cell in said series.

14. A flotation apparatus comprising a plurality of annular flotation cells concentrically arranged, intermediate annular compartments arranged between adjacent cells and adapted to receive the overflow froth from the adjacent outer cell and to feed such froth into the adjacent inner cell, and rotary stirrers associated with said intermediate compartments for breaking up the froth overflowing therein.

15. A flotation apparatus comprising a plurality of concentrically arranged annular compartments, each of said compartments having a porous bottom for the introduction of air, a circular wall depending into each of said annular compartments, except the outer thereof, and arranged to divide such compartment into a froth inlet compartment and a flotation compartment, the inner walls of said annular compartments being progressively lower from the outer to the inner so as to permit the progressive flow of froth from each flotation compartment to the next inner adjacent inlet compartment, and a rotary stirrer in each of said inlet compartments.

16. A flotation apparatus comprising a plurality of annular flotation cells concentrically arranged, said cells being arranged so as to direct the froth overflow of each cell into the next adjacent inner cell and so that the tailings of each cell escape into the next adjacent outer cell, and means for feeding the ore pulp to be treated to the outer of said cells and for withdrawing from said same cell the exhaust tailings of said apparatus.

17. A flotation apparatus comprising a plurality of annular flotation cells concentrically arranged, means for feeding the overflow froth from each of said cells, except the innermost one thereof, to the next adjacent inner cell, and means for breaking up the froth overflowing from one cell to another.

18. A flotation apparatus comprising a plurality of annular flotation cells concentrically arranged, means for feeding the overflow froth from each of said cells, except the innermost one thereof, to the next adjacent inner cell, means for permitting the escape by gravity of the tailings from each of said cells, except the outermost one thereof, to the next adjacent outer cell, and means for feeding the ore pulp to be treated and for withdrawing the exhaust tailings of said apparatus from the outermost cell thereof.

In testimony whereof I affix my signature.

JOHN F. MYERS.