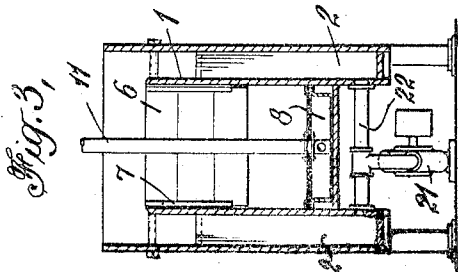
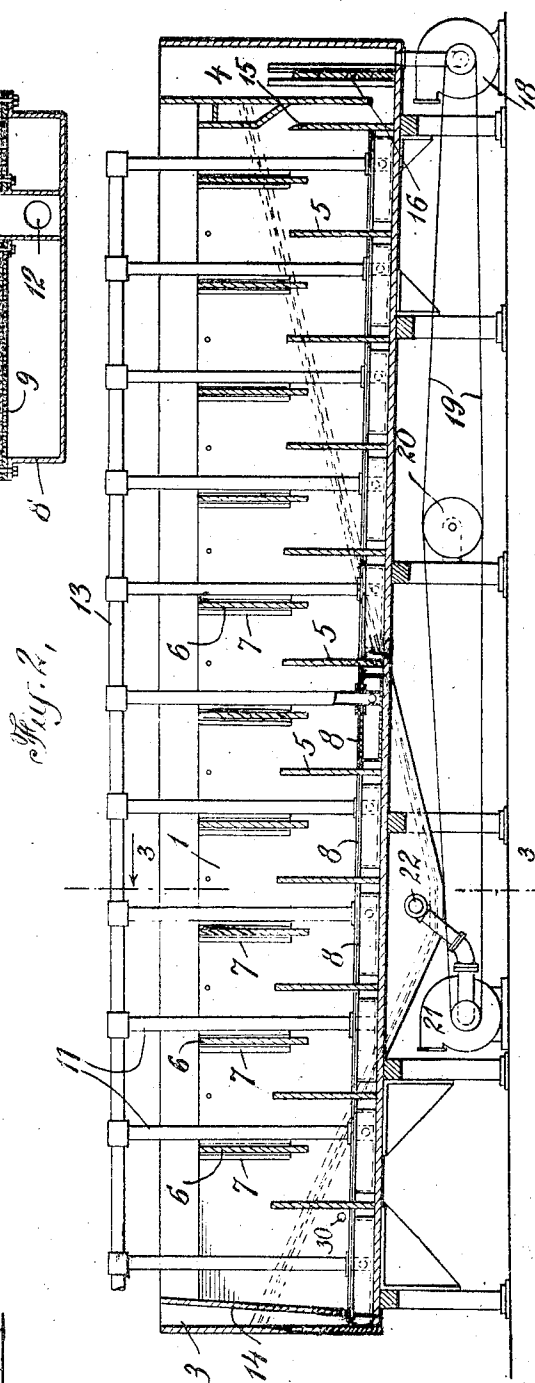
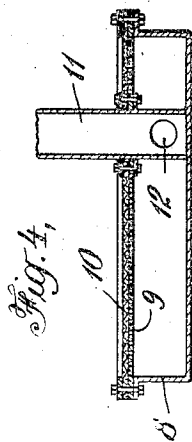
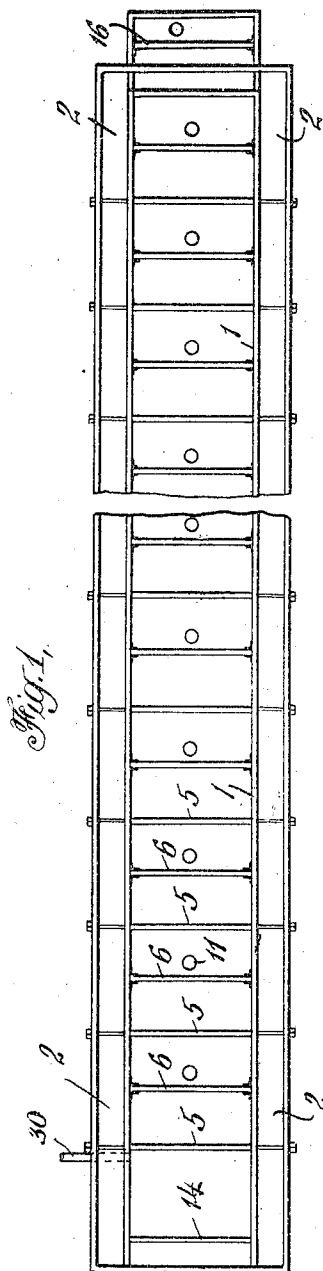


Dec. 26, 1922.

W. O. BORCHERT.
FLOTATION OF MINERALS.
FILED AUG. 30, 1919.

1,440,129

2 SHEETS-SHEET 1



Walter O. Borchert Inventor

By his Attorneys
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2 SHEETS-SHEET 2

Fig. 5,

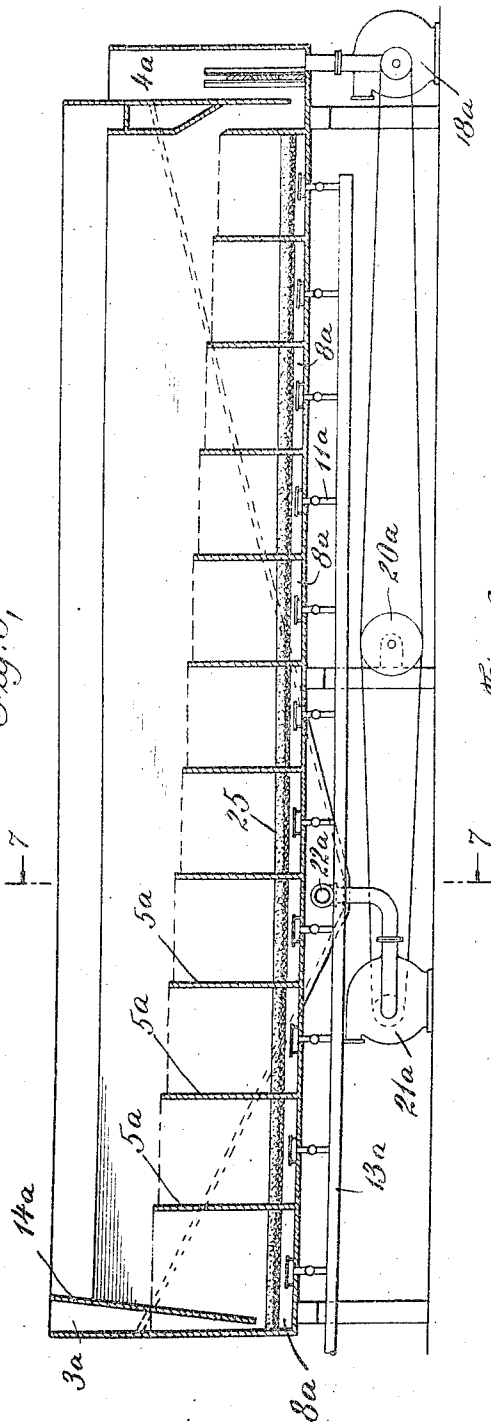


Fig. 6,

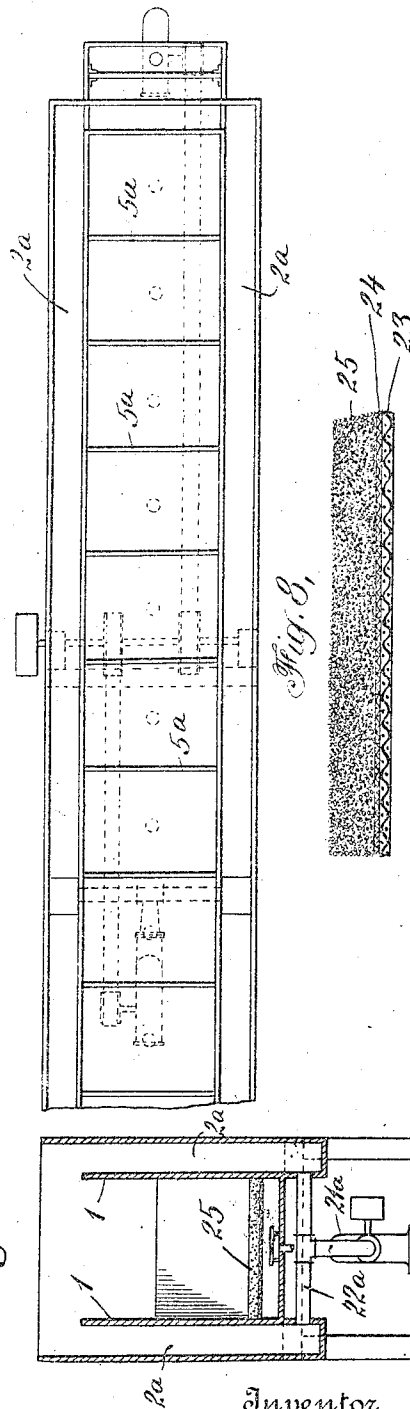
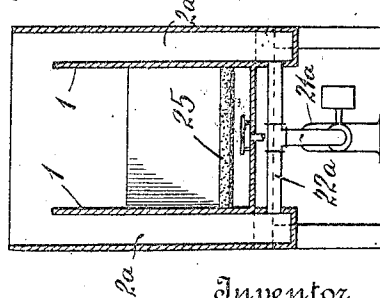


Fig. 7,



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UNITED STATES PATENT OFFICE.

WALTER O. BORCHERDT, OF AUSTINVILLE, VIRGINIA, ASSIGNOR TO THE NEW JERSEY ZINC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

FLOTATION OF MINERALS.

Application filed August 30, 1919. Serial No. 320,861.

To all whom it may concern:

Be it known that I, WALTER O. BORCHERDT, a citizen of the United States, residing at Austinville, in the county of Wythe, State of Virginia, have invented certain new and useful Improvements in Flotation of Minerals; 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 the flotation of ores and other substances amenable to flotation. More particularly, it relates to improvements in the so-called pneumatic process of flotation, in which the air or other gaseous fluid is introduced into the ore pulp through the porous bottom of the flotation cell, or its equivalent, and, as the pulp contains a suitable frothing and flotation agent or agents, the floatable constituents are raised by the air bubbles and caused to overflow as a froth, into suitable launders, whilst the non-floatable constituents, together with the bulk of the water, are eventually discharged from the end of the cell as tailings. In flotation apparatus of this general type, the ore pulp is introduced continuously at one end of the flotation cell, and the tailings pass out at the opposite end thereof, the froth being removed by overflow into the launders.

It has been the common practice to provide such flotation cells with a rather steeply inclined bottom, through which the air is introduced, the inclination of the bottom assisting in the prevention of settling of the solids of the pulp and the consequent obstruction or blanketing of the porous material forming the bottom. Such steeply inclined porous bottoms in flotation cells are, however, objectionable. These objections are in part as follows: Steep inclination of the porous bottom results in a great variation of the depth of pulp in different portions of the cell, and, since the rate of flow of the air thru the porous bottom is in part a function of the head of pulp above the porous bottom, it follows that in order

to maintain an approximately uniform 50 emission of air, the pressure of compressed air at the shallow end of the cell must be made less than that at the deep end of the cell. In order to make such regulation possible, the porous bottom is ordinarily divided by partitions into a plurality of air-boxes, the length of each of which, measured on the length of the cell, is comparatively small. Each of these individual air-boxes or compartments must be separately piped 60 from the main air supply header, and be equipped with an independent valve for regulating the flow of air, and even when this is done the usual result is that more air is emitted from the upper edge of the porous top of the air-box than from its lower edge. Such steeply inclined bottoms also have the effect of hastening the passage, thru the cell, of the coarser particles of valuable mineral, which, by their greater weight, naturally tend to remain near the bottom, thereby defeating the object of the process to the extent to which this occurs, as it will be plain that the more difficult a particle of valuable mineral is to float, the more 75 important it is to subject it repeatedly to conditions under which its flotation may become possible, so as to insure, to the greatest possible extent, its ultimate removal by the froth; and obviously, if a coarse particle of 80 valuable mineral which tends to hug the bottom, is carried thru the cell, not only at the rate corresponding to the average rate of flow of the whole pulp, but at an increased velocity, due to the component of gravity 85 fall, which the steeply inclined bottom tends to impart, it will be subjected to the action of the cell for a shorter period than that of the average particles of the pulp, and as it approaches the deep or discharge end 90 of the cell, the probability of its being carried into the froth becomes increasingly more remote. A further disadvantage of steeply inclined flotation cell bottoms results from the reduction in internal cubic 95 contents for a given floor space and mill height occupied by the cell. This loss in volume with the steeply inclined bottom

may range from 15 to 30% of the volume, which could have been secured within the same horizontal and vertical limits by a cell having a horizontal or approximately horizontal bottom. For example, if the volume of a cell included within certain horizontal and vertical dimensions, is a thousand gallons, and it is fed with pulp at the rate of 100 g. p. m. the average duration of exposure of a particle in the pulp should be 10 minutes, and it is one of the primary objects in the design of such cells to insure each particle of the same treatment, both as to time and intensity, as all other particles. If, by the steep inclination of the bottom 20% of the possible volume has been lost, the result will be a loss of 20% of the possible duration of treatment, irrespective of the considerations previously mentioned, whereby the steep inclination of the bottom reduces the average duration of treatment of the coarser particles.

Various mechanical devices have at different times been proposed to prevent the settling of portions of the pulp, and the consequent blanketing of the porous air-emitting surface, but, such mechanical devices have been of very limited utility, since they have, in general, operated to hasten, rather than retard, the rate of progress thru the cell of the coarser or less amenable particles of valuable mineral. The need for such mechanical devices has resulted chiefly from the irregular and uneven emission of air thru the porous bottom, since it is obvious that under conditions where a substantially uniform emission of air is provided, the settling of particles small enough to be within the range of flotation should be impossible.

In pneumatic flotation cells of all types, it has been customary to provide baffles extending from the froth overflow line, or slightly above it, down into the body of the pulp. Such baffles are generally arranged transversely to the length of the cell, and are ordinarily in an approximately vertical plane, their purpose being to prevent the longitudinal movement of the froth, causing it to overflow where formed, making possible, when desired, the collection of rich froth from the feed end of the cell, and leaner froth from the lower end of the cell, while at the same time localizing the effect of excessive free oil, or other froth breaking or "froth killing" agencies.

So also, it has been proposed to provide flotation cells of this same general character with a horizontal or but slightly sloping bottom, and to provide downwardly extending baffles with their lower edges separated a short distance from the upper surfaces of the porous bottom so that a scouring effect is thereby produced by the pulp flowing through the cell and the tendency to-

ward blanketing of the porous bottom thereby reduced.

According to the present invention the ore pulp is supplied to one end of a flotation cell in a continuous manner and continuously progressed therethrough, and the tailings and froth are continuously discharged therefrom but the ore pulp is subjected to the flotation operation in a series of successive bodies, from one to another of which the ore pulp successively flows, and which bodies are maintained substantially separate, except for the ore pulp which is continuously flowing into and out therefrom.

In the improved apparatus of the present invention, the flotation cell, which is of the pneumatic type, is provided with a plurality of partitions extending upwardly from the cell bottom and dividing the lower portion of the cell into a series of separate compartments, each provided with a porous bottom, or its equivalent, through which the air or other gaseous fluid is introduced. The height of the partitions separating the different compartments is such that the ore pulp, in flowing from one compartment to the next, is caused to pass upwardly towards the under surface of the froth as it passes over each partition. The action of the partitions is, therefore, to provide a series of successive bodies of pulp, from one to another of which the ore pulp flows in such a manner that each body of pulp is independently subjected to the flotation operation, and values continuously removed therefrom, while the ore pulp flowing from one compartment to the next is caused to pass upwardly towards the under surface of the froth.

The action of the partitions extending upwardly from the bottom of the flotation cell can be supplemented by depending baffles extending downwardly to, or a few inches below, the pulp line, so that the ore pulp, in passing through the cell, must pass alternately over the upwardly extending partitions, and then under the depending baffles.

The nature of the invention will be further described in connection with the accompanying drawings, illustrating certain embodiments of the apparatus of the invention, in which the process of the invention can be practiced.

In the accompanying drawings,

Fig. 1 is a plan view of an apparatus illustrative of the invention;

Fig. 2 is a vertical sectional view of the flotation cell or apparatus of Fig. 1;

Fig. 3 is a transverse vertical section taken on the line 3-3 of Fig. 2;

Fig. 4 is an enlarged view of one of the air compartments.

Fig. 5 is a vertical longitudinal section of a modified construction illustrative of the invention;

Fig. 6 is a plan view of the apparatus of Fig. 5;

Fig. 7 is a sectional view on the line 7—7 of Fig. 5; and

Fig. 8 is an enlarged view of one form of porous bottom.

Referring first to the apparatus illustrated in Figs. 1 to 4, it will be seen that the cell is constructed with the usual side walls 1 and launder 2, and with the inlet 3 at one end of the cell for the supply of the ore pulp and the outlet 4 at the other end for the removal of the tailings. Extending upwardly from the bottom of the cell are the partitions 5, of substantially the same height, so that the tops of the partitions lie in a plane substantially parallel to the plane of the bottom of the cell. The bottom of the cell is slightly inclined from the inlet 3 to the outlet 4 so as to provide the desired flow of the pulp through the cell by the action of gravity. Intermediate the partitions 5 are depending baffles 6, which are adjustable in guides 7, and which extend down to, or a few inches below, the normal pulp line of the cell. These baffles can be raised or lowered to different heights, but they will be arranged at such a height from the bottom of the cell that no appreciable scouring effect upon the bottom of the cell is occasioned thereby, and the principal object in positioning them between guides is to make them readily removable when it is desired to inspect or replace an air chamber or compartment.

It will be noted that the partitions divide the apparatus into a series of compartments, in each of which is provided means for the introduction of a compressed gaseous fluid, such as compressed air, by means of which the flotation is to be effected. In the form of the invention illustrated, the air compartments 8 are formed of a metal box having a perforated metal cover 9 thereon, above which are arranged the layer or layers of canvas or other material 10. The compressed air or other gaseous fluid is supplied by the supply pipes 11, which have transverse openings 12 communicating with the compartments 8. The various parts of the compartment are secured together in any suitable manner.

A common header 13 is provided for supplying the compressed air to the supply pipes 11 of the various compartments of the cell, and these various supply pipes can be provided with regulating valves (not shown) for independently regulating the supply of compressed air to the separate compartments. Inasmuch as the bottom of the cell is substantially horizontal, the difference in the head of pulp will vary but little from one end of the cell to the other, and the variation in the air pressure required will be correspondingly moderate.

The flotation cell is provided with the

usual baffle 14, to prevent interference by the inflowing pulp, and with the outlet compartment 4 containing the adjustable outlet partition 16. The tailings flowing from the apparatus are pumped by the pump 18 to another flotation machine for retreatment, or to other place of treatment, or to waste. This pump may be driven by any suitable means, as by a pulley 20 and the belt 19. A similar pump 21 is arranged to receive the froth from the launders 2 through the pipe 22, and pump it to its place of further treatment.

In the operation of the apparatus, the ore pulp or like material to be subjected to the flotation operation is introduced at the inlet end of the apparatus and is caused to flow progressively from one to another of the separate compartments formed by the partitions 5. In each of these compartments it is subjected to a flotation operation, while the partitions force the heavier portions of the ore pulp upwardly toward the under surface of the froth at each passage of the pulp thereover. The flotation of such particles is thereby promoted. Whereas, in the ordinary type of pneumatic flotation cell, whether of the steeply inclined bottom or of the substantially horizontal bottom kind, and whether or not equipped with baffles depending from the top and extending either just below the body of froth, or almost to the air-emitting surface, the tendency is toward hastening thru the cell the coarser particles of valuable mineral, or those less amenable to flotation, the arrangement of the cell of the present invention is such that the heavier particles, or those less amenable to flotation, are held in the cell for at least as long a period as any others. In the first compartment, included between the feed end of the cell 3, and the first partition 5, there is formed what amounts to a trap, in which are caught and retained particles too coarse to be carried thru the cell by the normal rate of flow, and the suspension resulting from the passage of the myriad of air bubbles thru the pulp. Such unduly coarse particles may be intermittently or continuously discharged from this first compartment by means of a bottom spigot or side-draw as will be readily understood by those skilled in the art, and as is commonly practiced with ore classifiers. The body of froth held above the first compartment between the feed end of the cell, and the first depending baffle 6, acts as is commonly the case with such baffles, and as described above, to localize the influence of any unemulsified oil or other "froth killing" agent, which may chance to enter the cell and be carried into the froth. The depending baffles 6 cause the ore pulp to progress in a labyrinthine manner from one compartment to the next, overflowing the partitions 5 into the successive compart-

ments, and then passing under the depending baffles 6 before overflow into the next compartments. These depending baffles form separate bodies of froth which overflow from the particular compartments where they are produced. The function of the depending baffles 6 is secondary, and they may be placed either directly above the partitions 5, leaving a horizontal slot between the upper edge of partitions 5, and the lower edge of baffles 6; or they may be placed in any other desired position, with respect to partitions 5, to best suit the conditions existing in the particular cell.

In the apparatus of Figs. 5 to 7, similar parts are indicated by the same reference characters as in Figs. 1 to 4 with the suffix "a" appended thereto. The cell has a substantially horizontal bottom and is provided with partitions 5^a extending upwardly from the bottom to progressively decreasing heights, so that the ore pulp, in its passage through the cell, will be caused to overflow these partitions progressively from the inlet to the outlet end of the cell, and so that the ore pulp will be caused to flow by gravity from one compartment to the next and subjected to successive and progressive flotation operations in these separate compartments. The froth produced will, however, all be collected in the common launder 2^a.

In the apparatus of Figs. 5 to 7, the compressed air supply pipe 13^a is arranged below the cell and has branches 11^a supplying the compressed air to the air compartment 8^a at the bottom of the separate flotation compartments.

The porous bottom illustrated in this modification of the invention is made up of a layer of metallic spherules or shot 25, supported in any suitable manner, as by means of the layer of canvas 24 which, in turn, is supported by the screen 23. This form of porous bottom is more fully described in Letters Patent of the United States, No. 1,326,174, patented December 30, 1919. Such a layer of metallic spherules has the advantage of giving a substantially uniform discharge of air bubbles of uniform size. The depth of the layer of metallic spherules and the fineness of the spherules can be varied depending upon the desired fineness of the air bubbles to be produced. Spherules of a diameter of 0.08 inches to 0.03 inches or from No. 9 to fine dust American standard may be employed, and of a depth of from about one-half inch to one inch or even two inches or more. The depth of the layer of spherules or shot will naturally vary with the nature of the supporting diaphragm and with the result desired. With even very fine spherules the separate partitions 5 prevent the spherules from being carried from one compartment to another, even though the spherules may be somewhat disturbed

and agitated by the upward passage or discharge of air therethrough.

It will accordingly be noted that the present invention provides an improved flotation cell or apparatus of the pneumatic type, in which the cell is divided into a series of compartments, from one to another of which the ore pulp flows, with the result that the ore pulp is subjected to the flotation operation in a series of successive and more or less independent bodies, while the ore pulp, in its overflow from one compartment to the next, is caused to pass upwardly so that the heavier portions are directed toward the under surface of the froth at each passage over the partitions and the flotation operation thereby promoted.

The treatment of the ore pulp in the improved apparatus accordingly involves, as a method of treatment or procedure, the supplying of the ore pulp in a continuous manner to the flotation apparatus, and the subjecting of the pulp therein to a series of progressive and successive flotation operations, during each of which the ore pulp is subjected to the pneumatic flotation, and between which the ore pulp is caused to flow upwardly so that the heavier portions of the pulp are forced toward the under surface of the froth successively and repeatedly, and the flotation operation thereby promoted, while the froth formed is continuously and separately removed.

It will, of course, be understood that flotation agents of various kinds can be used in the process and apparatus of the present invention, much as they have heretofore been commonly used in the pneumatic flotation process. The flotation agent, such as an oil or mixture of oils, can thus be preliminarily incorporated with the ore pulp before it is supplied to the flotation cell, so that, during the passage of the ore pulp through the cell, the flotation agent will be present and will promote the flotation operation, in a manner which will be readily understood.

I claim:

1. The method of concentrating minerals and other floatable substances by the pneumatic process of flotation, which comprises continuously supplying ore pulp to a flotation apparatus and removing the tailings therefrom, subjecting the ore pulp in its flow through said apparatus to a series of separate and successive flotation operations in the course of each of which operations the ore pulp is caused to flow downwardly, repeatedly directing the ore pulp (in its flow through said apparatus) upwardly toward the under surface of the froth during the passage of the ore pulp from one flotation operation to a successive flotation operation and while the ore pulp is continuously subjected to the flotation operation and so that the regions of the pulp upflow as well as the

regions of pulp downflow are longitudinally extended and overlies regions of delivery of fine gas bubbles, and continuously removing the froth formed.

5 2. A flotation apparatus of the pneumatic type provided with a series of partitions extending upwardly from the bottom of the apparatus and dividing the same into a series of separate compartments and adapted to
10 cause an ore pulp flowing through the apparatus to flow downwardly and then upwardly in each compartment, means for introducing finely divided air or other gaseous fluid into the bottom of each of said com-
15 partments, and means for supplying ore pulp to one end of the apparatus and for removing the tailings from the other end of the apparatus, whereby the ore pulp in its flow through the apparatus from one com-
20 partment to the next is caused to overflow the partitions and is thereby directed upwardly toward the under surface of the froth while being continuously subjected to the flotation operation, the aforementioned gas
25 introducing means being so arranged that the regions of pulp upflow as well as the regions of pulp downflow are longitudinally extended and overlies regions of delivery of fine gas bubbles.

30 3. A flotation apparatus of the pneumatic type provided with a series of partitions extending upwardly from the bottom of the apparatus and dividing the same into a series of separate compartments, means for intro-
35 ducing finely divided air or other gaseous fluid into the bottom of each of said compartments, downwardly extending baffles operatively arranged in said apparatus and so spaced from said partitions and from the
40 bottom of the apparatus as to provide unrestricted passages for the flow of ore pulp between the partitions and baffles and beneath the baffles, and means for supplying ore pulp to one end of the apparatus and for removing
45 the tailings from the other end of the apparatus, whereby the ore pulp in its passage through the apparatus from one compartment to the next is caused to overflow the partitions and flow under the depending
50 baffles while being continuously subjected to the flotation operation, the aforementioned gas introducing means being so arranged that the regions of pulp upflow as well as the regions of pulp downflow are longitudinally
55 extended and overlies regions of delivery of fine gas bubbles.

4. A flotation apparatus of the pneumatic type provided with a series of partitions extending upwardly from the bottom of the
60 apparatus to progressively decreasing distances and dividing the apparatus into a series of separate compartments, means for introducing finely divided air or other gaseous fluid into the bottom of each of said
65 compartments, and means for supplying ore

pulp to one end of the apparatus and for removing the tailings from the other end of the apparatus, whereby the ore pulp in its passage through the apparatus from one com-
partment to the next is caused to overflow
70 the partitions and is thereby directed upwardly toward the undersurface of the froth.

5. A flotation apparatus of the pneumatic type provided with a series of partitions extending upwardly from the bottom of the
75 apparatus and dividing the apparatus into a series of separate compartments, depending baffles operatively arranged in said apparatus and so spaced from said partitions and
80 from the bottom of the apparatus as to provide unrestricted passages for the flow of ore pulp between the partitions and baffles and beneath the baffles, means for supplying ore pulp to one end of the appara-
85 tus and for removing the tailings from the other end of the apparatus, whereby the ore pulp in its passage through the apparatus from one compartment to the next is caused to overflow the partitions and flow under the
90 depending baffles, and means for introducing finely divided air or other gaseous fluid into the bottom of each of said compartments so that the regions of pulp upflow as well as the regions of pulp downflow are longitudi-
95 nally extended and overlies regions of delivery of fine gas bubbles.

6. A flotation apparatus of the pneumatic type provided with a series of partitions extending upwardly from the bottom of the
100 apparatus to progressively decreasing distances and dividing the apparatus into a series of separate compartments, means for supplying ore pulp to one end of the apparatus and for removing the tailings from
105 the other end of the apparatus, whereby the ore pulp in its passage through the apparatus from one compartment to the next is caused to overflow the partitions, and means for introducing finely divided air or other gas-
110 eous fluid into the bottom of each of said compartments so that the regions of pulp upflow as well as the regions of pulp downflow are longitudinally extended and overlies regions of delivery of fine gas bubbles.
115

7. A flotation apparatus of the pneumatic type provided with a series of partitions extending upwardly from the bottom of the apparatus to progressively decreasing distances and dividing the apparatus into a
120 series of separate compartments, depending baffles operatively arranged in said apparatus and so spaced from said partitions and from the bottom of the apparatus as to provide unrestricted passages for the flow of
125 ore pulp between the partitions and baffles and beneath the baffles, means for supplying ore pulp to one end of the apparatus and for removing the tailings from the other end of the apparatus, whereby the ore pulp in 13

its passage through the apparatus from one compartment to the next is caused to overflow the partitions and flow under the depending baffles, and means for introducing
5 finely divided air or other gaseous fluid into the bottom of each of said compartments so that the regions of pulp upflow as well as the regions of pulp downflow are longitudinally extended and overlie regions of delivery of fine gas bubbles. 1

In testimony whereof I affix my signature.

WALTER O. BORCHERDT.