Nov. 19, 1946. A. R. MORSE 2,411,288

FROTH FLOTATION WITH SIMULTANEOUS FILTRATION AND COLLECTION OF FROTH

Filed March 26, 1945 2 Sheets-Sheet 1

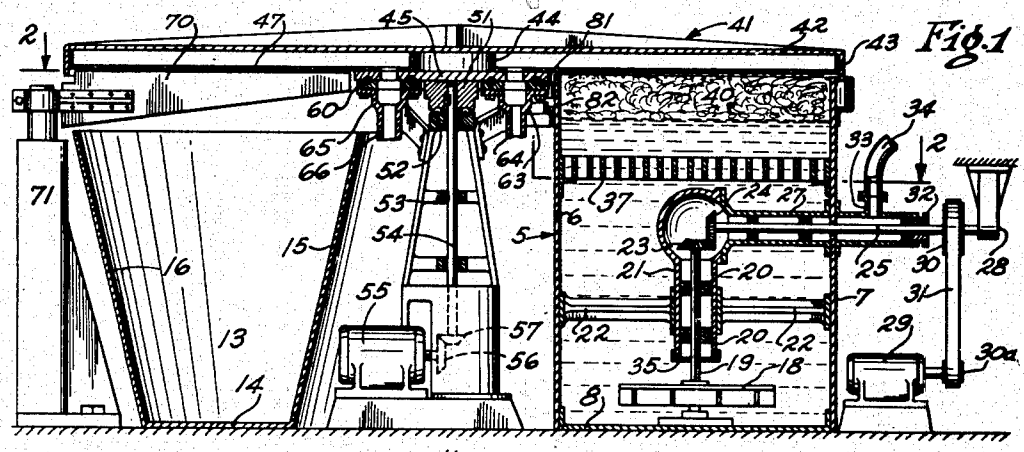


Fig. 1

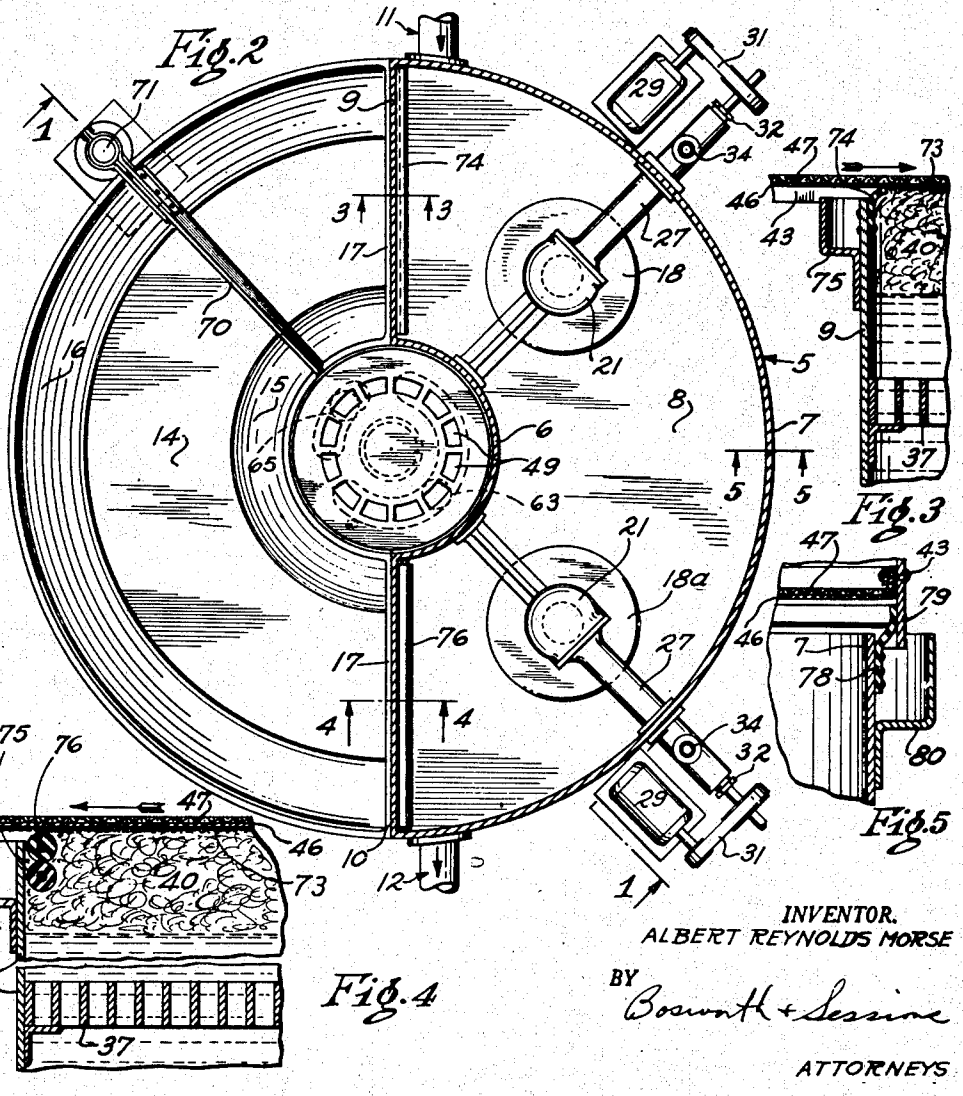


Fig. 2

Fig. 3

Fig. 4

Fig. 5

INVENTOR.
ALBERT REYNOLDS MORSE

BY Bosworth + Sessions

ATTORNEYS

Nov. 19, 1946. A. R. MORSE 2,411,288

FROTH FLOTATION WITH SIMULTANEOUS FILTRATION AND COLLECTION OF FROTH

Filed March 26, 1945 2 Sheets-Sheet 2

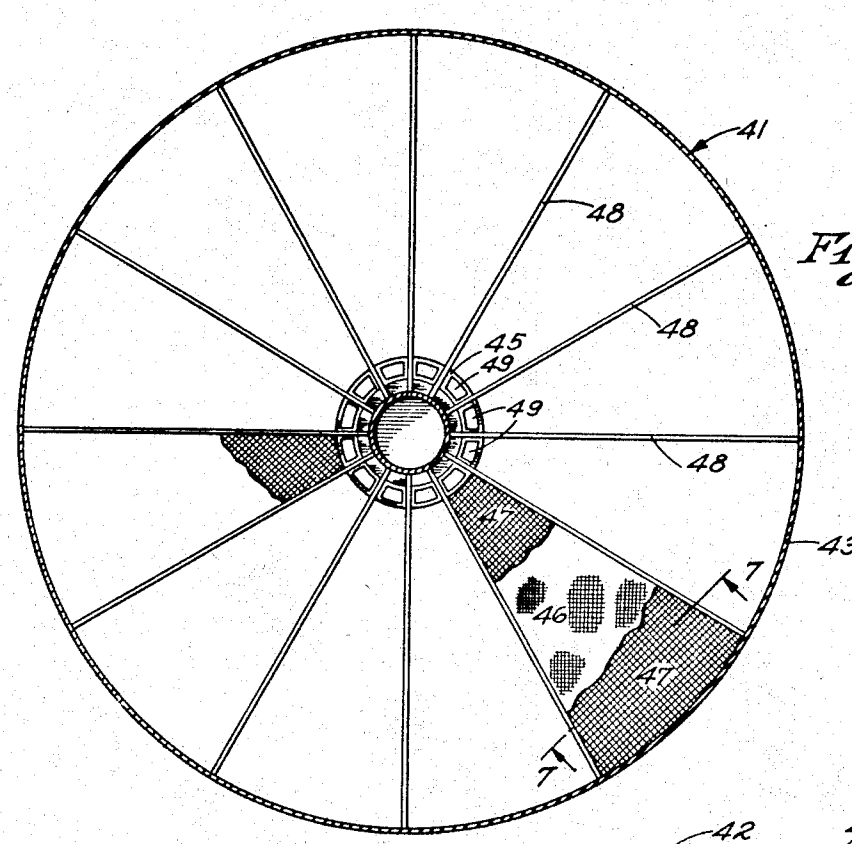


Fig. 6

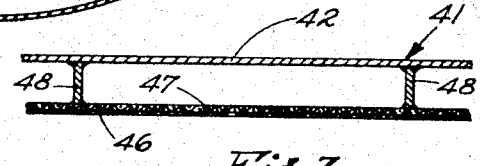


Fig. 7

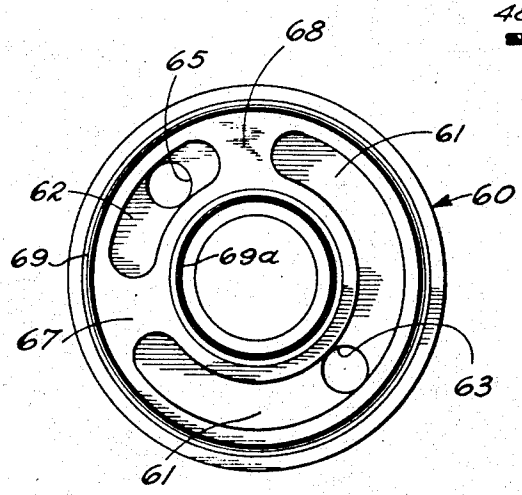


Fig. 8

INVENTOR.
ALBERT REYNOLDS MORSE
BY
Bowman & Session
ATTORNEYS

Patented Nov. 19, 1946

2,411,288

UNITED STATES PATENT OFFICE

2,411,288

FROTH FLOTATION WITH SIMULTANEOUS FILTRATION AND COLLECTION OF FROTH

Albert Reynolds Morse, Shaker Heights, Ohio

Application March 26, 1945, Serial No. 584,913

12 Claims. (Cl. 209—164)

1

This invention relates to a method and apparatus for separating or concentrating the valuable constituents of mineral ores, i. e., the separation or concentration of the more valuable mineral or minerals from the worthless part of the ore, or gangue. More particularly the invention relates to the recovery of the valuable minerals, metals or concentrates from flotation cells.

The general objects of the invention are the provision of a method of separating or concentrating the valuable minerals, metals and the like (hereinafter collectively referred to as "concentrates") contained in mineral ores at a decreased cost and with increased efficiency as compared to present methods, and the provision of a simple and effective apparatus for carrying out the method. More specific objects are the provision of an economical and efficient method and an apparatus for carrying out the method whereby concentrates of low moisture content can be recovered from the froth produced by flotation cells.

The flotation method of separating valuable minerals from ore is well known and widely used. According to the ordinary practice, a watery mixture known as "pulp," containing the ore to which the proper quantity and kind of oil or other reagent has been added, is beaten by an agitator or other means producing a froth on the top of the cell which contains the concentrates which it is sought to recover. These mineral concentrates are heavier than water, but are supported by the froth above the liquid level and are ordinarily removed from the cell by mechanically skimming the froth from the cell. The froth containing the concentrates is diluted with water for convenience in handling and then pumped to a settling tank or thickener, and finally to a filter where the concentrates are separated from the water and discharged into a bin.

According to the present invention, the concentrates are recovered directly from the undiluted froth, preferably from the upper surface of the flotation cell by a downwardly facing surface disposed in contact with the froth, then the surface is removed from the froth, carrying with it the concentrates, which are thereafter discharged from the surface directly into a bin. Preferably the surface is composed of a suitable filter material, such as a permeable fabric. The surface preferably is continuous, and is moved through a path such that each portion thereof is moved across the top of the

2

flotation cell in contact with the froth, then away from the cell where accumulated concentrates are removed, and then across the cell again, and so on. I prefer to reduce the pressure behind that portion of the filter in contact with the froth and apply pressure to the portion over the bin to discharge the concentrates therefrom. That portion of the filter in contact with the froth continuously picks up concentrates from the undiluted froth, the concentrates being continuously removed in the region adjacent the bin. Thus the mechanism required for mechanically skimming the filter cells is eliminated, the dilution of the concentrates by water is done away with, and the necessity for pumping the diluted concentrates to the thickener and filter obviated, resulting in substantial decreases in operating, installation and capital costs as compared to present practices. Furthermore, by controlling the liquid level in the cell, the filter element may be positioned in contact with the froth at the level containing the greatest amount of concentrates, insuring efficient operation. The froth is continuously renewed by the operation of the agitators or the like, and fresh pulp is supplied to the cell in the usual manner. The arrangement is preferably such that the concentrates are picked up continuously from the entire surface of the cell, thereby insuring rapid and efficient operation. The method may be carried out rapidly and economically by sturdy and compact apparatus which can be constructed at relatively low cost and which requires substantially less investment in equipment and mill space than the usual apparatus required to do the same amount of work.

A preferred form of apparatus for carrying out my method is illustrated in the drawings in which Figure 1 is a vertical section through a flotation cell embodying my invention and showing a preferred form of filter apparatus for removing the concentrates from the cell, the section being taken as indicated by line 1—1 of Figure 2; Figure 2 is a horizontal sectional view taken along line 2—2 of Figure 1; Figures 3, 4 and 5 are sectional details on an enlarged scale taken along the lines 3—3, 4—4 and 5—5, respectively, of Figure 2; Figure 6 is a plan view of the filter element with parts broken away to show the construction thereof; Figure 7 is a sectional detail of the filter element taken along the line 7—7 of Figure 6; and Figure 8 is a detail illustrating a preferred form of valve plate for controlling the application of suction and pressure to the filter element.

As shown particularly in Figures 1 and 2, an apparatus embodying my invention comprises a flotation cell, which for the sake of compactness of the entire apparatus, preferably but not necessarily is made in arcuate form, occupying about 180° of arc. The cell comprises the arcuate or semi-annular tank indicated generally at 5 and having an inner curved or arcuate wall 6, an outer wall 7, a bottom wall 8, and radial end walls 9 and 10. The tank may be constructed of sheet metal in any conventional manner, the parts being secured together as by riveting or welding. An intake 11 is disposed at one side of the tank near the bottom thereof, the pulp being introduced through this intake in the usual manner. The tailings may be discharged through the outlet 12 disposed at the opposite side of the tank from the intake 11. To receive the concentrates recovered from the cell, I preferably provide an arcuate or semi-annular bin 13, complementary to the tank 5, and made up of a bottom plate 14, curved side walls 15 and 16, and radial end walls 17. This arrangement lends itself to the use of a continuously rotated annular filter element disposed over the annulus made up of the tank 5 and bin 13.

In order to agitate the pulp and generate the froth, agitators 18 and 18a are provided within the tank 5. These may be of any conventional construction, and while I have shown two such agitators in the preferred embodiment, it will be understood that if desired only a single agitator may be employed or more than two agitators may be used, depending upon the size and shape of the cell, and the materials being handled. While the agitators themselves may be of any conventional construction, they are preferably driven by mechanisms such as shown in the drawings, rather than by the conventional overhead or vertical drive mechanisms. The agitators 18 and 18a and their respective driving mechanisms are preferably identical; accordingly only the driving mechanism for agitator 18 will be described in detail. The same reference characters are applied to similar parts in both mechanisms. Preferably, agitator 18 is rotated at a speed of, for example, about 1800 R. P. M. by a shaft 19 which is supported in suitable bearings 20 in a housing 21 mounted in tank 5 by the supporting brackets 22. At its upper end the shaft 19 is provided with a beveled gear 23 which is engaged by the beveled gear 24 mounted on the horizontal shaft 25. The shaft 25 is carried in suitable bearings in the horizontal housing member 27 and by the outboard bearing 28, and is driven by motor 29 through pulleys 30 and 30a and belt 31.

It will be noted that the shaft 25 passes through a packing or stuffing box 32 as it leaves the housing 27, and the housing 27 is provided with a lateral inlet 33 to permit air under pressure to be supplied to the interior of the housing through the conduit 34. By this means a slight positive pressure may be maintained within the housings 21 and 27, maintaining the level of any liquid that might leak past the end member 35 into the housing 21 below the level of the lower bearing 20. Thus, the bearings and gears of the agitator drive are protected from possibility of damage by the abrasive pulp contained in the tank 5. Also, if desired, air can be supplied to the tank through the conduit 34 and housings 27 and 21, being discharged into the pulp at the lower end of the housing 21.

The usual anti-turbulence grid 37 is provided at the customary level. The pulp level is maintained substantially constant by conventional float controls and valves, not shown. As is customary, the float controls can be adjusted to vary the pulp level to provide the optimum yield.

Upon operation of the impellers or agitators 18, a layer of froth carrying the concentrates and comprising enormous numbers of minute bubbles is formed in the usual manner on the top surface of the liquid pulp as indicated diagrammatically at 40. In order to remove the concentrates from the cell, I preferably employ a filter indicated generally at 41 and shown best in Figures 1, 6 and 7. The filter is circular in form, is supported concentrically with tank 5 and bin 13, and may comprise a circular disk 42 having a downwardly extending cylindrical peripheral flange 43 and a similar cylindrical inner flange 44. The outer flange 43 has a radius slightly greater than the radius of the outer wall 7 of the tank, while a circular disk 45 having a radius slightly less than the radius of the inner wall 6 is secured to the lower edge of the flange 44. The annular space between the flange 43 and the edge of disk 45 is covered with filtering material, for example, canvas or other suitable fabric, 46 backed up by wire screen 47. The cloth 46 and screen 47 are spaced from the disk 42 and the space between the disk and the screen is divided into a plurality of segments by radially extending vertical partitions 48, the partitions separating the entire filter in effect into separate filter elements to each of which suction and pressure may be successively applied.

This last result is obtained by providing the plate 45 with a plurality of ports or openings 49 through which suction or pressure may be applied, there being one port or opening 49 for each segmental filter element. The plate 45 also functions to mechanically support the entire filter for rotation about its vertical axis, the plate being supported on block 51 carried by a suitable bearing 52 upon the pedestal 53. The entire assembly is rotated by the drive shaft 54, which is driven at relatively slow speed, for example one or two revolutions per minute, by the motor 55 through suitable reduction gearing (not shown) and beveled gears 56 and 57.

In order to apply suction to the filter segments when they are disposed in contact with the froth on top of the flotation cell and pressure to the segments when they are over the bin 13, I preferably employ a valve mechanism such as the valve plate 60 which is disposed immediately beneath the plate 45 and in sealing contact therewith. The plate 60 as shown particularly in Figure 8 has an arcuate suction port 61 and an arcuate pressure port 62 which are adapted to register with the openings 59 in the plate 45. The suction port 61 is connected through the manifold 63 to the conduit 64 leading to a vacuum pump, while the pressure port 62 is connected through the manifold 65 to the conduit 66 leading to a blower or other suitable source of fluid under pressure. If desired, sealing rings 69 and 69a may be provided to reduce leakage between the valve plate 60 and plate 45.

By this arrangement, each segmental filter element is connected with the vacuum line as the rotation of the entire filter brings each element successively over the flotation cell 5 with the filter cloth 46 in contact with the froth on the top of the cell. Each port 49 remains in communication with the vacuum line during the entire time that its associated segment is in contact with the froth and until such segment approaches the

scraper 70. The suction preferably is maintained as long as practical after the segment leaves the froth in order to remove additional moisture from the concentrates. As each segment approaches the scraper 70 in its travel over the receiving bin 13, its associated port 49 passes over the solid portion 67 of the valve plate 60, shutting off the suction connection momentarily, and then registers with the pressure port 62. Thereafter, each port 49 remains in communication with the pressure port 62, and thus with the source of air under pressure, as its associated segment travels in its arcuate path over the remaining portion of the arcuate bin 13. As each segment approaches the end of the bin the pressure is cut off by the solid portion 68, and then the suction connection is restored as the segment again comes in contact with the froth.

In operation, the suction, coupled with the well known tendency of the concentrate film to adhere to any surface, even though the bubbles making up the froth are broken, causes the concentrates contained in the froth to adhere to the underside of the filter cloth in the form of a paste or slime in spite of the fact that the concentrates are heavier than water. The layer or cake of concentrates builds up on the underside of the cloth of each segment as the segment travels around and over the flotation cell, and the concentrates are discharged into the bin 13 by the application of pressure to the interior of the segments when they are disposed above the bin. The scraper plate 70 is preferably provided to assist in the removal of the concentrates from the underside of the filter member. This may be mounted upon suitable support 71 (see Figures 1 and 2) and is arranged at an angle as shown to scrape the concentrates from the underside of the filter cloth and into the bin.

The action of the filter elements in picking up the concentrates from the froth is shown diagrammatically in Figures 3 and 4. As indicated in Figure 3, with the filter turning in a clockwise direction, the cloth 46 is substantially free from concentrates when it passes over the radial wall 9 of the tank 5. As it travels along in contact with the froth it accumulates a layer 73 of concentrates which is initially very thin as shown in Figure 3. This layer gradually becomes thicker as the filter travels across the tank in contact with the froth, attaining a substantially greater thickness, as shown in Figure 4, by the time the filter element leaves the froth and passes over the radial wall 10. The concentrates, which as compared to concentrates recovered by conventional methods contain a relatively small percentage of water, are then blown and scraped from the cloth in its passage over the bin 13 so that the cloth is substantially free from concentrates when it again reaches the entry side of the tank. In these figures, the layer of concentrates is necessarily indicated diagrammatically, and the drawings are not intended to show the relative thicknesses of the screen, the filter cloth and the layer; for the thickness of the layer of concentrates may vary within reasonably wide limits, depending upon the speed of operation, toughness of the bubble film, amount of suction, the nature of the materials being handled in the cell, the flotation oils or reagents, and other factors.

Figures 3 and 4 with Figure 5 also illustrate a preferred arrangement for preventing loss of the froth and overflowing of the flotation cell. This is preferably accomplished by mounting a flexible rubber flange member 74 on the radial

wall 9 and engaging the underside of the filter cloth as shown in Figure 3. A trough 75 is provided to catch any froth or liquid that may overflow the wall 9. At the exit side of the cell, a similar flange, bent in the direction of movement may be employed, or I may employ rolls 75 and 76 mounted in the tank adjacent the radial wall 10; the roll 75 being arranged to engage the layer of concentrates on the underside of the filter cloth. The two rolls together function to block the space between the top of the wall 10 and the filter cloth against excessive leakage, and at the same time to sufficient clearance to prevent the layer of concentrates being scraped as by the top of the wall 10. Here again, a trough member 77 is provided to catch any leakage.

Similar flange members are provided on the arcuate walls 6 and 7, Figure 5 showing the arrangement on the outer wall 7, which comprises a rubber flange member 78 mounted adjacent the upper part of the wall and adapted to slideably engage the depending portion 79 of the flange 43. For convenience in illustration, the liquid and froth are not shown in Figure 5. The trough member 80 is provided to catch any leakage. A similar flange member 81 mounted on the inner wall 6 (see Figure 1) engages the peripheral edge of the valve plate 45. The trough member 82 is provided to catch any leakage that may occur along this wall. By this arrangement, the filter member is substantially sealed against the upper edges of the tank 5 in its travel thereover. Because of the reduced pressure within the filter segments over the tank and because of the presence of the sealing members, there is no excessive leakage or overflow from the tank, although if desired, a positive pressure of a few inches of water may be maintained within the tank to assist in filtering action.

In operation, the pulp treated with flotation reagents in the usual manner is supplied to the cell through the intake pipe 11 and the tailings are withdrawn through the discharge pipe 12. The beaters or agitators 18 and 18a are driven by the motors 29 at customary speeds, for example 1800 R. P. M. This produces the desired froth 40 at the top of the cell. The liquid level and supply of fresh pulp is maintained by automatic regulators of known construction to provide a constantly renewed froth of the desired density in contact with the filter cloth 46. The motor 55 is operated to rotate the filter member slowly to bring successively the various filter segments into contact with the froth, carry them across the cell in contact with the froth and then move them away from the cell and over the bin 13. Through the valve mechanism, each segment is connected to the vacuum or suction line while it is over the flotation cell and in contact with the froth and each segment is connected with the source of pressure as it is over the bin 13 and approaching the scraper 70. Thus the minerals are gathered on the underside of the filter cloth as the segments pass over the cell and discharged from the filter cloth by the action of the pressure and by the scraper 70 as the filter segments pass over the bin. The speed of rotation of the filter is correlated with the density of the froth and the concentration of valuable minerals therein to obtain a coating or cake of concentrates of the desired thickness on the underside of the cloth. The thickness of the layer or cake may vary within reasonably wide limits, but it should not be so great that the layer will crack and fall back into the flotation cell,

nor should it be great enough to prevent or substantially impair the dewatering action of the filter, for the method and apparatus are preferably operated to produce concentrates of exceptionally low moisture content. The speed of operation of the filter may correspond generally with the speed of operation of conventional cylindrical filters, for example speeds of one or two revolutions per minute may be employed. A vacuum of from 17 to 20 inches of mercury is preferably applied to the filter when thin pulps are employed, and this may be increased to from 20 to 25 inches of mercury with denser pulps. Pressure up to 7 to 15 pounds per square inch may be aplied on the pressure side of the cycle to blow the pulp off the filter cloth into the bin.

From the foregoing description of a preferred form of my invention, it will be seen that by my method the usual operations of skimming the concentrates from the top of a flotation cell then diluting the concentrates with water and pumping them to thickeners and filters where the water is removed and the concentrates recovered, together with the various items of equipment necessary to carry out these operations, are all eliminated. Thus my method effects a substantial saving in the investment required to recover concentrates from flotation cells and operates to recover concentrates from such cells with greater efficiency, lower moisture content and at lower cost than has heretofore been possible. My preferred apparatus for carrying out my method is relatively simple and compact and can be manufactured and operated at reasonable cost.

Various changes and modifications can be made in my invention both as to method and apparatus without departing from the spirit and scope thereof. Therefore, it is to be understood that the foregoing description of my method and apparatus is given by way of example and not limitation, and that my patent is not limited to the preferred form disclosed herein or in any manner other than by the scope of the appended claims.

I claim:

1. The method of recovering heavier than water mineral concentrates from a concentrate-containing froth produced by a flotation cell, which comprises placing a permeable filter with its lower surface in contact with the undiluted froth, applying suction to the upper side of the filter thereby causing concentrates contained in the froth to adhere to the underside of the filter, thereafter removing the filter from the froth and applying gas under pressure to the upper side of the filter to discharge the concentrates therefrom.

2. The method of removing heavier than water mineral concentrates from a flotation cell wherein the concentrates are contained in froth at the top of the cell, which comprises placing a permeable filter with its lower surface in contact with the froth at the top of the cell and above the level of the liquid therein, applying suction to the upper side of the filter thereby causing concentrates contained in the froth to adhere to the underside of the filter, thereafter removing the filter from the froth and removing the accumulated concentrates therefrom.

3. The method of removing heavier than water mineral concentrates from a flotation cell wherein the concentrates are contained in the froth at the top of the cell, which comprises continuously moving a permeable filter into contact with the froth in the cell, with the filter disposed in a substantially horizontal plane, applying suction to the upper side of the portion of the filter in contact with the froth thereby causing concentrates contained in the froth to adhere to the underside of the filter, continuously removing the filter from the froth and applying gas under pressure to the upper side of the portion thereof out of contact with the froth to discharge the concentrates therefrom.

4. The method of removing heavier than water mineral concentrates from a flotation cell wherein the concentrates are contained in froth at the top of the cell, which comprises moving a continuous filter element in a path such that during a portion of its travel its lower surface is in contact with the froth in the cell and during another portion is out of contact with the froth, applying suction to the upper surface of that portion of the filter element in contact with the froth thereby causing concentrates to accumulate on the lower surface in contact with the froth, the movement of the filter element carrying the accumulated concentrates away from the froth, and removing the accumulated concentrates during the portion of travel of the element in which the element is out of contact with the froth.

5. Apparatus for recovering concentrates from a flotation cell wherein the concentrates are contained in froth at the top of the cell, comprising, in combination with the flotation cell, a round filter mounted for rotation about a vertical axis and positioned to have one portion disposed over the cell with its lower surface adapted to contact with froth in said cell and another portion spaced away from the cell, means for applying suction to the portion of the filter adapted to contact the froth whereby concentrates may be accumulated thereon, means for removing accumulated concentrates from a portion of the filter spaced away from the cell, and means for rotating said filter, whereby concentrates may be continuously accumulated on said filter and continuously removed therefrom.

6. Apparatus for recovering concentrates from a flotation cell wherein the concentrates are contained in froth at the top of the cell, comprising, in combination with the flotation cell, a round, substantially plane filter of greater area than the cell mounted for rotation about a vertical axis and positioned to have one portion disposed over the cell with its lower surface adapted to contact with froth in said cell and another portion spaced away from the cell, sealing means mounted on the walls of the cell and engaging the under surface of said filter for preventing substantial overflow of froth and liquid from said cell, means for applying suction to the portion of the filter adapted to contact the froth whereby concentrates may be accumulated thereon, means for removing accumulated concentrates from a portion of the filter spaced away from the cell, and means for rotating said filter, whereby concentrates may be continuously accumulated on said filter and continuously removed therefrom.

7. Apparatus for recovering concentrates from a flotation cell wherein the concentrates are contained in froth at the top of the cell, comprising, in combination with the flotation cell, a round filter mounted for rotation about a vertical axis and positioned to have one portion disposed over the cell with its lower surface adapted to contact with froth in said cell and another portion spaced away from the cell, sealing means mounted on the walls of the cell and engaging the under surface of said filter for preventing substantial overflow of froth and liquid from said cell, means for apply-

ing suction to the portion of the filter adapted to contact the froth whereby concentrates may be accumulated thereon, means for applying pressure to a portion of the filter spaced away from the cell to remove accumulated concentrates therefrom, and means for rotating said filter, whereby concentrates may be continuously accumulated on said filter and continuously removed therefrom.

8. Apparatus for recovering concentrates from ores, comprising a flotation cell comprising a tank having means for creating a concentrate-containing froth on the surface of pulp within the tank, a bin, an annular filter member mounted for rotation about a vertical axis, said filter member comprising an annular chamber having a lower surface of filter material, a portion of which is disposed over said tank and adapted to contact froth therein, while another portion is disposed over said bin, radial partition members dividing said annular member into a plurality of segmental filter elements, means for rotating said filter member to pass said segmental filter elements successively over said tank and said bin, and valve means for successively connecting said filter elements to a source of suction when they are over said tank and to a source of pressure when they are over said bin.

9. Apparatus for recovering concentrates from ores, comprising a flotation cell comprising a tank having means for creating a concentrate containing froth on the surface of pulp within the tank, a bin, an annular filter member mounted for rotation about a vertical axis, said filter member comprising an annular chamber having a lower surface of filter material, a portion of which is disposed over said tank and adapted to contact froth therein, while another portion is disposed over said bin, radial partition members dividing said annular member into a plurality of segmental filter elements, means for rotating said filter member to pass said segmental filter elements successively over said tank and said bin, and valve means for successively connecting said filter elements to a source of suction when they are over said tank.

10. Apparatus for recovering concentrates from ores, comprising a flotation cell comprising an arcuate tank having means for creating a concentrate containing froth on the surface of pulp within the tank, a bin, an annular filter member concentric with said tank and mounted for rotation about a central vertical axis, said filter member comprising an annular chamber having a lower surface of filter material, a portion of which is disposed over said tank and adapted to contact froth therein, while another portion is disposed over said bin, radial partition members dividing said annular member into a plurality of segmental filter elements, means for rotating said filter member to pass said segmental filter elements successively over said tank and said bin, valve means for successively connecting said filter elements to a source of suction when they are over said tank whereby concentrates are accumulated thereon as said elements pass over said tank, and means for removing said concentrates from said elements and discharging said concentrates into said bin.

11. Apparatus for recovering concentrates from ores, comprising a flotation cell comprising an arcuate tank having means for creating a concentrate containing froth on the surface of pulp within the tank, said tank extending for approximately 180° of arc, an arcuate bin concentric with the tank and extending for the remainder of the circular arc of the tank, an annular filter member concentric with said tank and bin and mounted for rotation about a central vertical axis, said filter member comprising an annular chamber having a lower surface of filter material, a portion of which is disposed over said tank and adapted to contact froth therein, while the remainder is disposed over said bin, radial partition members dividing said annular member into a plurality of segmental filter elements, means for rotating said filter member to pass said segmental filter elements successively over said tank and said bin, and valve means for successively connecting said filter elements to a source of suction when they are over said tank and to a source of pressure when they are over said bin.

12. In combination with a flotation cell having means for creating a froth containing heavier than water mineral concentrates on the surface of the pulp within the cell, apparatus for recovering said concentrates from said froth comprising a rotatably mounted round filter positioned to have one portion disposed with its lower surface adapted to contact undiluted froth, and another portion spaced away from the froth, means for applying suction to the portion of the filter adapted to contact the froth whereby concentrates may be accumulated on the under surface thereof, means for applying gas pressure to a portion of the filter spaced away from the froth to remove accumulated concentrates therefrom, and means for rotating said filter, whereby concentrates may be continuously accumulated on said filter and continuously removed therefrom.

ALBERT REYNOLDS MORSE.