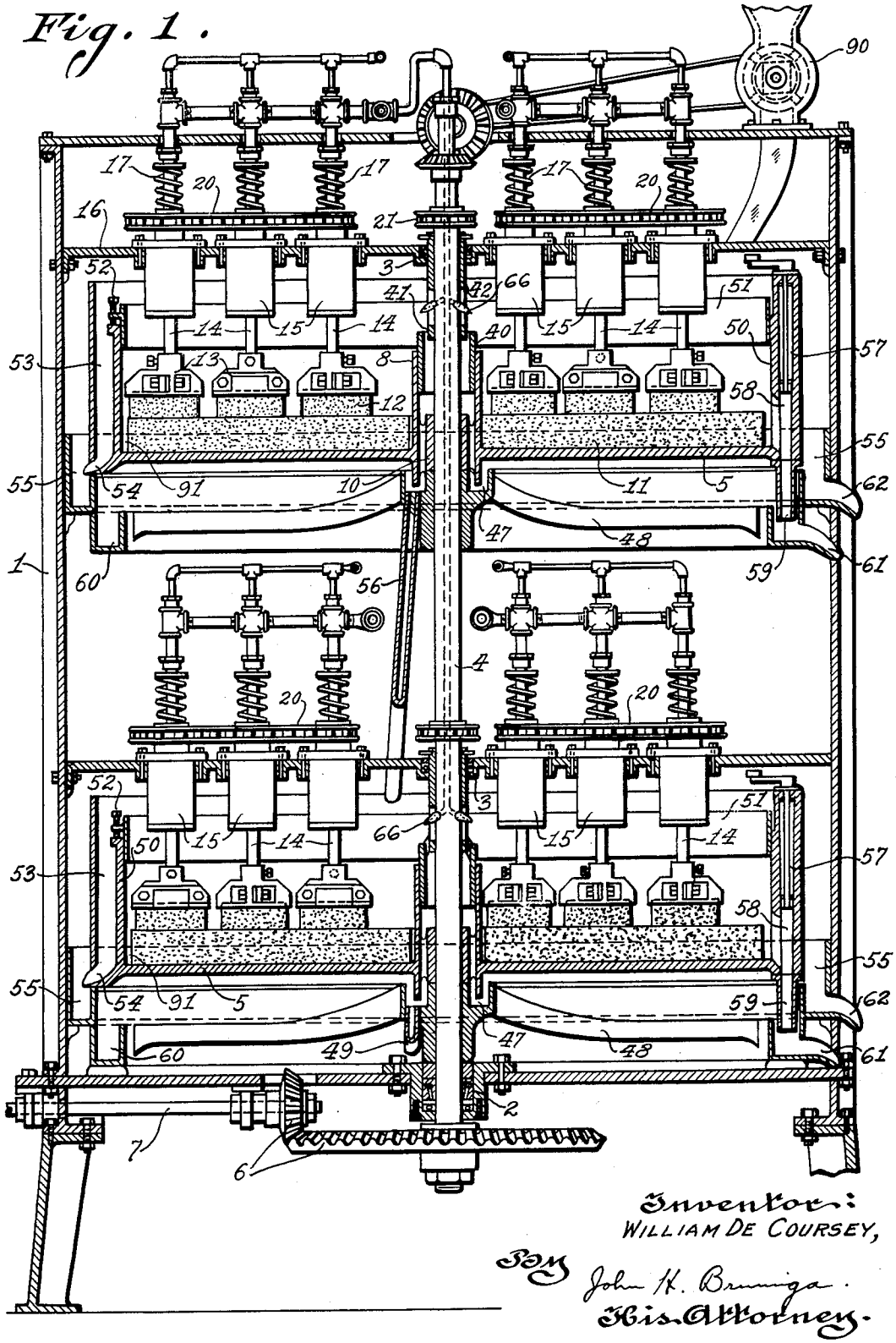
May 8, 1934. W. DE COURSEY 1,958,035

METHOD AND APPARATUS FOR TREATING MATERIALS

Filed April 11, 1927 3 Sheets-Sheet 1

Fig. 1.



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METHOD AND APPARATUS FOR TREATING MATERIALS

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Fig. 2.

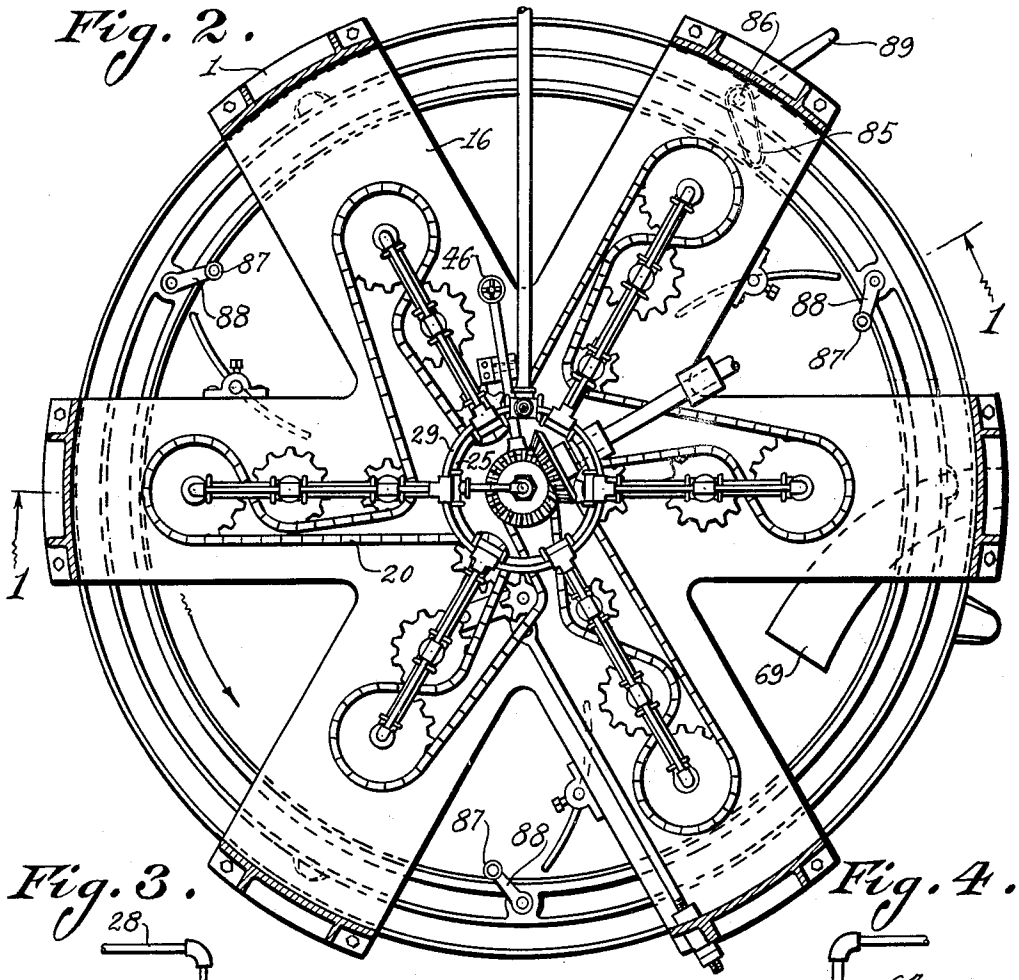


Fig. 3.

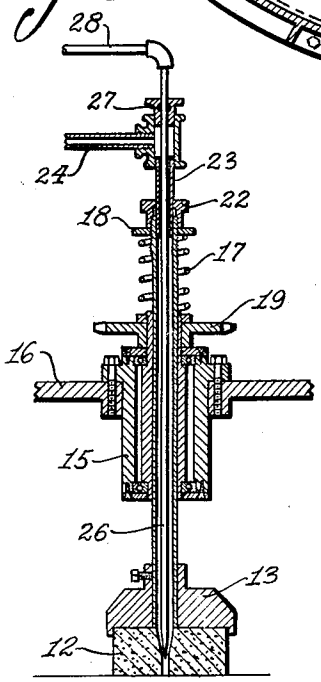
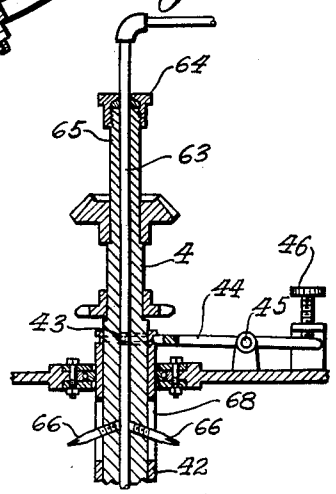


Fig. 5.



Fig. 4.



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METHOD AND APPARATUS FOR TREATING MATERIALS

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Fig. 6.

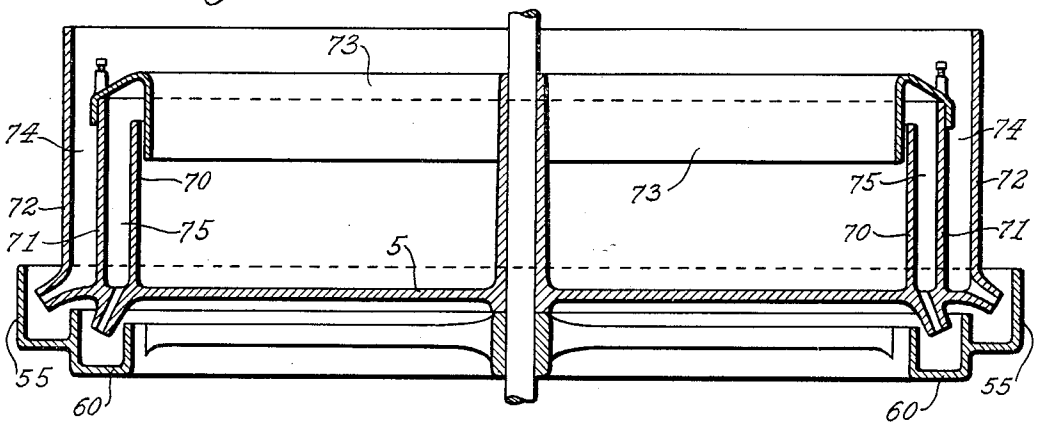
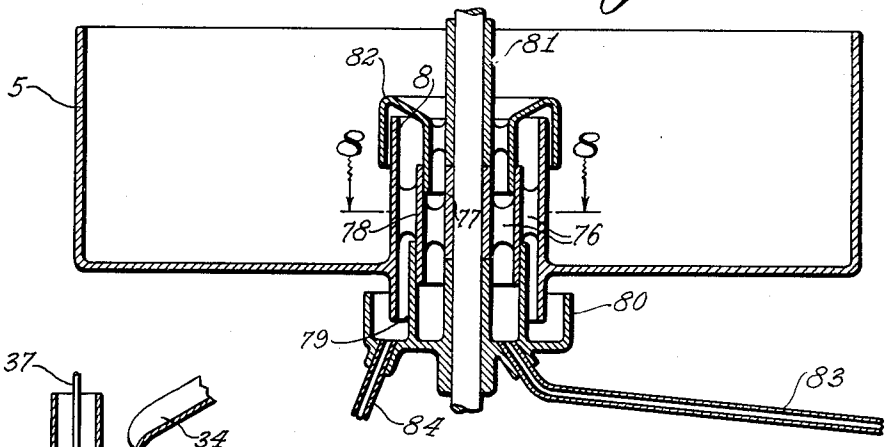


Fig. 7.



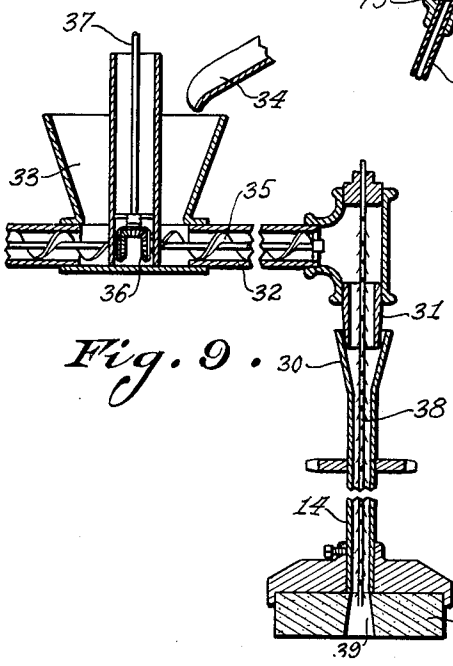
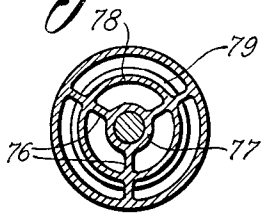


Fig. 9.

Fig. 8.



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UNITED STATES PATENT OFFICE

1,958,035

METHOD AND APPARATUS FOR TREATING MATERIALS

William De Coursey, St. Louis, Mo.

Application April 11, 1927, Serial No. 182,883

17 Claims. (Cl. 209—12)

This invention pertains to a method and apparatus for treating materials. The invention has been applied more particularly to the treatment of ores and the like, and the method involves the use of the flotation process for separating and handling ores.

In carrying out flotation processes, it has been the practice to introduce into a liquid bath the ore or like material in a more or less finely pulverized condition and, after adding a small percentage of a reagent of a suitable nature, to agitate the mixture in the bath. In some processes arrangements have been provided for introducing air into the bath. The agitation of the bath causes a more or less thorough mixture of the ingredients contained therein and tends to keep the ground material in suspension in the liquid. The reagent introduced usually has a selective action in that it acts upon one ingredient to a greater extent than upon another, or it may not act upon the second ingredient at all. For instance, oil introduced into a bath containing certain pulverized ores has a tendency to attach itself to and form a coating upon the particles of the mineral, while it has practically no action upon other particles consisting mostly of gangue material. The difference in the action of the reagent upon different ingredients causes a difference in the tendency of the two to float or even to become wetted by the liquid. In the above mentioned case, the oil coating on the mineral tends to prevent a particle from becoming wet, while the gangue particles are not so protected. The result of these conditions is that, when the mixture is agitated and air in small bubbles is introduced into the liquid, the protected ingredient has a tendency for its particles to attach themselves to the air bubbles and be carried thereby to the top of the liquid to float thereon in the form of a froth of greater or less depth, according to the nature of the material operated upon. This procedure is known generally as the flotation process of separating materials, and the materials are separated by the difference in their tendency to float on the liquid. After flotation, one ingredient may be removed by removing the froth from the top of the liquid, while the other ingredient remains at the bottom thereof.

One of the objects of this invention is to provide a method and apparatus whereby such a flotation process may be carried out in a more rapid and efficient manner.

Another object is to provide a method by which the ingredients may be separated in a continuous operation.

Another object is to provide a method in which the material may be ground in the same bath in which flotation is carried out.

Another object is to provide a method by which excessive grinding may be avoided.

Another object is to provide a method wherein certain parts of the separation may be carried out by amalgamation or like process, while other parts are carried out by flotation.

Another object is to provide a method and apparatus whereby the air or the reagent or both may be introduced to the material or to the bath during the grinding process.

Another object is to provide novel and efficient apparatus for carrying out the various methods.

Further objects will appear from the following description, taken in connection with the accompanying drawings, in which—

Figure 1 is a vertical sectional view of a machine embodying this invention and adapted for carrying out the method thereof;

Figure 2 is a plan view of Figure 1;

Figure 3 is a sectional view of one of the muller shafts;

Figure 4 is a partial sectional view of the main shaft;

Figure 5 is a perspective detail view of an air nozzle;

Figure 6 is a sectional view of a pan illustrating another embodiment of this invention;

Figure 7 is a view similar to Figure 6 illustrating still another embodiment of this invention;

Figure 8 is a section on line 8—8 of Figure 7;

Figure 9 is a sectional view of a muller shaft illustrating another embodiment of this invention, whereby the material may be fed through the muller shaft; and

Figure 10 is a detail section showing the outlet valve.

Referring now to the accompanying drawings, 1 designates a frame or support, which has mounted therein, in suitable bearings 2 and 3, a vertical shaft 4. This shaft has mounted thereon, so as to rotate therewith, one or more pans or drums 5 adapted to contain liquid. The shaft 4 may be driven in rotation by suitable gearing 6 driven by a shaft 7 from any suitable source of power, not shown. In the embodiment shown in Figure 1, each pan 5 is provided with a sleeve 8 providing an internal upstanding rim surrounding the shaft 4 and providing a channel through which liquid may pass downwardly out of the pan. The rim 8 is connected by spider arms 9 to a hub 10, which is fixed to the shaft 4.

Mounted within the pan 5 on the bottom thereof

is a plate 11 of abrasive, such as carborundum or the like. Upon the upper face of the plate 11 rest a series of mullers, each comprising a block 12 of abrasive material mounted in a clamping head 13 on the lower end of a muller shaft 14. The shaft 14 may be carried in a suitable bearing 15 removably mounted in a supporting spider 16 carried by the frame 1. The weight of the muller and shaft is partly or wholly supported by a spring 17 surrounding the muller shaft 14 and supporting a nut 18 screwed on the upper end of the shaft 14 and adapted for adjustment to adjust the tension of the spring 17. This spring supports the muller shaft and in turn rests upon a sprocket 19 splined to the muller shaft and supported on the bearing 15, as will be seen more particularly from Figure 3. The sprockets 19 may be connected by means of a chain 20 with a driving sprocket 21 on the shaft 4, so as to drive the mullers in rotation when the shaft 4 turns.

It will be seen that, by this construction, rotation of the shaft 4 will carry the pans 5 in rotation therewith and will also drive each of the mullers 12 in rotation upon its own shaft 14. The mullers are placed at various distances from the center of rotation of the plate 11, as seen in Figure 2, so that the relative movement of the plate and the mullers is such that the mullers will sweep the entire surface of the plate as the latter rotates, and each muller rotating on its own axis will co-operate with the plate to grind any material which may be placed thereon. If the pan 5 is filled with liquid, this grinding will take place beneath the liquid, and the movement of the pan with reference to the stationary mullers will agitate the liquid so that the ground material will be stirred up and kept in suspension therein.

Each muller shaft 14 has provisions for introducing air or a chemical reagent or both, as shown in detail in Figure 3. The shaft 14 is hollow and has provided at the upper end thereof a stuffing box 22 through which passes a stationary pipe 23 connected by a radial pipe 24 with a supply pipe 25 in the form of a ring around the shaft 4 at the upper part of the machine. The air may pass downwardly from the pipe 24 through the hollow shaft 14 and out through a central perforation in the block 12.

Within the hollow shaft 14 is mounted a pipe 26, which extends upwardly and passes out of said pipe through a suitable fixture 27 and then radially inwardly by a pipe 28 to a second supply pipe 29 positioned similarly to the supply pipe 25. By these means, a reagent, such as oil, may be introduced to the bath while the mullers are in operation. The pipe 26 may extend downwardly to a point close to the bottom of the block 12, so that the reagent may be delivered directly to the grinding point.

In some cases it may be desirable to feed the material to be ground into the bath through the muller shafts 14. In such a case the construction shown in Figure 9 may be employed. In this case, the hollow shaft 14 is flared at its upper end, as indicated at 30, to provide a hopper. A pipe 31 suitably supported above the hopper 30 extends thereinto and communicates with a radial pipe 32, which in turn communicates with a hopper 33 mounted over the center of the machine and adapted to receive a supply of material from a suitable source 34. A suitable breaker or conveyor 35 may be mounted in each of the pipes 32, so as to prevent lodgment of the material therein or to actually move the material therealong. These conveyors may have a gear connection 36 with a shaft 37 driven by any suitable source of power, not shown. A similar breaker 38 may be fixed in position within the shaft 14, so that as said shaft rotates, the stationary breaker will operate to prevent lodgment or bridging of the material. The lower end of the shaft 14 opens into the flaring perforation 39 in the block 12, so as to permit the material to feed downwardly to the grinding point.

It will be seen that provision is made for supplying air or a reagent or both to the material in the bath and, if desired, directly at the grinding point. The action of these materials on the ore being treated is, as has been previously pointed out, to cause a portion of the material to float on the surface of the bath in the form of a froth. Provision is made for removing the froth as it is formed and also for removing the liquid containing the gangue material.

The rim or sleeve 8 is provided with an adjustable top edge in the form of a sleeve 40, having a fairly close sliding fit within the sleeve 8 and connected by spider arms 41 to a sleeve 42 sliding on the shaft 4. The upper end of the sleeve 42 may be provided with an annular groove adapted to receive a pair of rollers 43 on a forked lever 44 pivoted at 45 on the spider 16 and adjustable by means of a screw 46 bearing on the outer end thereof. By this construction, the sleeve 40, which provides an upper rim or edge for the sleeve 8, is adjustable vertically so that the height of this rim relatively to the height of the liquid in the pan may be adjusted.

The adjustable rim 40 may be raised or lowered to such a height as to be just below the top of the froth, which lies upon the surface of the liquid or just even with said surface and below the upper level of the froth or at any suitable height so as to cause the froth to spill over the edge of the rim 40 and into the interior of the sleeve 8, where it may pass downwardly around the shaft 4 to a cup or basin 47, surrounding the shaft 4 and supported by spider arms 48 on the frame 1, as will be more fully described later. The basin 47 may be provided with a suitable outlet 49 adapted to carry off the material which collects therein to any suitable point for further treatment.

As it may in some cases be desirable to discharge the froth from the bath at its outer edge, instead of its inner edge, the peripheral wall 50 of the pan 5 may also be provided with an adjustable rim 51, which may be adjusted by screws 52 or other suitable means. This rim may also be adjusted to a suitable height with reference to the height of the froth on the bath so that the froth will spill thereover into an annular channel 53 formed on the outside of the pan. The outer channel 53 may be provided with one or more outlets 54 adapted to discharge into an annular trough 55 extending around the pan and supported on the frame 1.

This construction provides for a method of operation in which the material, after being caused to float upon the bath, is permitted to pass over the rim 51 into the channel 53 and drawn off in the trough 55. The floating material, in other words, is skimmed from the bath at the external portion thereof.

By a suitable adjustment of both of the rims 40 and 51, both the froth and the liquid containing the gangue material may be drawn off simultaneously at different points. As the pan 5 is in rotation, the liquid therein will be thrown out of its ordinary level condition by centrifugal

force, and the outer portion thereof will stand at a higher level than the inner portion. Consequently, the outer rim 51 may be adjusted to skim off the froth from the surface of the liquid without permitting any of the liquid itself to discharge at that point. At the same time, the inner rim 40 may be adjusted to a lower level in accordance with the lower level of the liquid at the inner part thereof and so as to permit said liquid to pass over the rim 40 and down the sleeve 8. The action of centrifugal force will also prevent the froth from passing over the rim 40 so long as it is permitted to pass outwardly over the rim 51. The liquid, however, being unable to pass over the rim 51, may be drawn off over the rim 40 by simply adjusting the latter to a sufficiently low level. In this way a continuous process may be carried on in which the froth is being continually formed and drawn off, while the liquid containing the gangue is drawn off at another point.

In Figure 1 the upper basin 47 is provided with an outlet pipe 56 extending downwardly and discharging into the lower pan. This provides for carrying out a continuous process in which the liquid containing the gangue material, after being drawn off from the upper bath, may be fed to the lower one, where it may be reprocessed in any desired manner. The lower bath being similarly equipped to the upper one, can also be adjusted so as to draw off the separated materials, as described above.

So long as the apparatus remains in operation, the ground material is kept in suspension in the liquid by the agitation set up by the mullers. If the rotation of the pan were to be stopped, however, the ground material would settle to the bottom in a thick cake, which would prevent starting the machine again until such cake had been removed by digging out or a similar operation. In order to prevent this action, provision is made for drawing off the material and emptying the pan before stopping its rotation. For this purpose, one or more valves 57 may be provided at suitable intervals around the rim of the pan for draining the latter through an opening 58 to a suitable spout 59 discharging into an annular trough 60 mounted below the pan adjacent the trough 55 and supported thereon or on the frame 1. The trough 60, as well as the trough 55, may be provided with suitable outlets 61 and 62, respectively, from which the material may be drawn off in any desired manner.

As shown in Figure 1, the spider arms 48, carrying the basin 47, may be supported on the trough 60, which in turn is supported on the frame 1. In order to assist in the thorough separation of the froth, pneumatic means for moving the froth may be provided. The shaft 4 may be provided with an air passage 63 extending down the center thereof, as shown in Figure 4. The upper end of the shaft may be provided with a suitable stuffing box 64, through which a stationary pipe 65 enters the passage 63. The pipe 65 may be connected with any suitable source of air supply, not shown. At intervals around the shaft 4 and at a suitable height with respect to the level of the liquid in a pan 5, the shaft is drilled to receive a series of spray nozzles 66, communicating with the passage 63. These nozzles have flared ends, whose exit is in the form of a narrow slit 67, adapted to project a fan shaped jet of air therefrom. These nozzles pass through slots 68 in the sleeve 42 so as to permit the movement of said sleeve along the shaft. By means of these nozzles, a jet of air may be caused to impinge upon the froth on the surface of the liquid in the pan. This jet may be adjusted to any desired degree of intensity adapted to move the layer of froth outwardly over the bath and to discharge the same over the rim 51. Means are provided, therefore, to gently move the froth along the surface of the bath without danger of rupturing the bubbles of which it is composed.

Instead of discharging the froth over either the outer or the inner rim of the pan, it may be desirable to remove the same by skimming from the surface with a suitable scoop. Such a scoop is indicated at 69 in Figure 2. If this scoop is made adjustable radially of the bath in any suitable manner, the material may be scooped from any desired point thereof.

Since the bath is in rapid rotation and the froth has considerable momentum, it may easily be scooped up over the rim of the pan and discharged on the outside thereof.

As it may be desirable to withdraw both the froth and the gangue liquid from either the outer or the inner rim of the pan, constructions suitable for such use are illustrated in Figures 6 and 7. In Figure 6 the pan is provided with three outer walls, 70, 71 and 72. These walls increase in height progressively from the inner to the outer one. Mounted on the intermediate wall 71 is an adjustable rim 73 of substantially U-shaped cross section, which fits over the outside of the wall 71 and extends inwardly so as to overhang the inner wall 70, leaving a substantial clearance therebetween. The rim 73 may be adjusted to any desired height with reference to the height of the froth so that the latter will pass over the said rim and into an outer channel 74 to be drawn off into the trough 55. The inner portion of the rim 73 extends downwardly within the wall 70 so as to permit only liquid from the lower level to pass upwardly over the wall 70 and into the channel 75 to be discharged into the trough 60.

This construction provides that a continuous process may be carried out in which the froth is continually passing over the rim 73 and down through the channel 74, while the gangue liquid, taken from a lower level, passes over the wall 70 and into the channel 75. These separated materials may thus be drawn off continuously. It is understood, of course, that the grinding plate 11 and mullers 12 may also be used in this embodiment.

In the construction of Figure 7, the sleeve 8 is carried by a series of spider arms 76 on a hub 77, similar in all respects to the hub 10. Formed intermediate in length of the arms 76 is an annular rim or sleeve 78. There are thus formed vertical passages both inside and outside of the sleeve 78. The lower end of the sleeve 78 fits just inside of an inner upstanding rim 79 formed in a basin 80 mounted below the pan 5. The rim 79 divides the basin 80 into inner and outer compartments, one communicating with the passage on the interior of the sleeve 78 and the other with the passage on the exterior of said sleeve. Mounted on an adjustable sleeve 81, similar in all respects to the sleeve 42 but slidable along the shaft 4 and fixed in adjusted position by a set screw or the like, is a guard or rim 82. This guard is substantially U-shaped in cross section and fits snugly inside of the sleeve 78, while its outer edge overhangs and extends somewhat below the upper rim of the sleeve 8, a substantial clearance being allowed between the two.

By this construction, the rim 82 may be ad-

justed to such a height that the froth on the liquid will pass thereover and down the passage on the interior of the sleeve 78 and into the inner compartment of the basin 80. At the same time, the gangue liquid drawn from a point below the upper level thereof passes upwardly between the guard 82 and the sleeve 8, over the rim of the latter and down the passage on the exterior of the sleeve 78 to be discharged into the outer compartment of the basin 80. These inner and outer compartments may be provided with outlets 83 and 84, respectively, by which the material may be drawn off.

It will be seen that this construction provides for the operation of a continuous process, in which both the froth and the gangue liquid may be drawn off continuously as they are formed. In this case also it is understood that the grinding elements may be used in the pan 5.

The valves 57 may be mounted in a boss in the channel 75 or may be otherwise suitably applied to the pan of Figure 6 as shown in Figure 10 for drawing off all the material prior to stopping the machine. In the pan of Figure 7 a boss might be formed on the interior of the rim to receive the valve 57. The operation of these valves while the machine is running may be accomplished by a dog 85 pivoted at 86 on the spider 16 and adapted to engage a roller 87 on a crank arm 88 mounted at the upper end of the valve stem. The dog 85 may be thrown so as to operate the valve to open or close the same by means of a handle 89.

It will be seen that this invention provides improved means for carrying out the operations of a flotation process, and improved methods for carrying out such process. In accordance with the method of this invention, the material to be treated may be fed to the bath in a coarse, unground condition. The material is ground in the bath in which the flotation operation is carried out. Since the flotation of the materials takes place as soon as the proper degree of fineness is attained in the grinding, it will be apparent that the material leaves the grinding point as soon as a suitable degree of fineness has been attained, and thus excessive regrinding of the same material or grinding to unnecessary fineness is avoided. Consequently, the energy involved in grinding is considerably reduced and the time required very much shortened.

The treatment of the material with a reagent for causing selective flotation is carried out at the grinding point, as the reagent is injected actually between the grinding surfaces. Accordingly, that material which is ground to sufficient fineness is treated at once and floats immediately. Furthermore, the admission of air may also be directly at the grinding point, so that the finely ground material may be brought immediately into contact with a supply of air bubbles which will carry it to the surface at once. These steps may be carried out separately or in combination. The action of the mullers on the liquid produces an agitation of the liquid in addition to the grinding action which those mullers have on the material being treated. Such agitation not only keeps the ground material in suspension in the liquid, but the grinding itself beneath the liquid serves to provide an initial agitation which puts the newly ground material directly into suspension in the liquid.

While the above description points out how the reagent may be supplied to the bath directly at the grinding point, it must be understood, of course, that other means and methods of adding the reagent may be used. For instance, dry reagents may be added to the material before the same is added to the bath for grinding. In such a case not only the material to be treated but also the reagent will be subjected to a thorough grinding and mixing operation, in which intimate contact between the two is assured.

Carrying out the flotation process in a rotating bath makes it possible to separate the floating material from the gangue by skimming. This may be carried out either by skimming the froth over the rim of the pan, either interiorly or exteriorly, or it may be removed by a scoop, as previously pointed out. The rotation also provides for handling the separated materials in such a way that the treatment may be made continuous. The material may be fed to the bath continuously and at a predetermined rate, as by means of a suitable feeding device. The fixed rate of adding material will then provide a fixed rate of grinding and of flotation, and, accordingly, when the rims 40, 51, 73 and 82, which form the spillways for the material, are properly adjusted, the removal of the froth may also be carried on at a fixed rate. Accordingly, a continuous process is possible in which every operation is under absolute control.

It will be understood, of course, that other means for adding air for the flotation reagent may be used. The same may be passed into the bath by any suitable piping arrangement and need not necessarily be passed in through the muller shafts, although this method is very convenient and effective.

The separation of the froth is materially assisted by the jet of air from the nozzles 66. This jet may be adjusted so that a very gentle and continuous flow of air impinges upon the froth so as to move it gently outwardly over the rim.

The arrangement of Figure 1, in which two or more pans may be mounted one above the other, provides for a successive separation of different ingredients. The reagent supplied to the first bath may be different from that supplied to succeeding baths, so that one ingredient at a time may be removed from the liquid and the latter passed to a succeeding bath in which another reagent operates to separate a second ingredient, and so on. In this way a successive separation of different ingredients may be carried out and all the operations combined into one continuous process, in which a material having a number of valuable ingredients enters the process at the beginning and, after successively separating the several valuable ingredients, a gangue is discharged at the conclusion of the process which is practically free of valuable materials.

It will be noted in Figure 1 that the plate 11 is somewhat smaller in diameter than the inside of the pan 5, so as to leave an annular groove or channel 91 around the outside of the plate. By placing mercury in this channel a combination of the amalgamation and flotation processes may be carried out. The rotation of the bath causes the mercury to spread itself over the wall 50 of the pan in a sheet of greater or less thickness. During the grinding process of such materials, which may be treated by amalgamation, it often happens that particles of free mineral of comparatively large size are set free before the grinding has progressed to its final state of fineness. Such large particles being heavy will be thrown outwardly by centrifugal force and brought into contact with the mercury film. Amalgamation

will, of course, immediately take place. It will thus be clear that the larger particles of the valuable mineral may be taken up by the amalgamation process even before the grinding has progressed very far. These large particles are more readily liberated since they are acted upon to a greater extent than the finer particles by centrifugal force and, accordingly, are immediately thrown outwardly to the mercury film. The finer particles, which are not liberated until a certain degree of fineness is attained in the grinding, may not be so readily acted upon by centrifugal force, but may have a greater tendency to remain in suspension in the liquid. Such particles will not be so readily brought into contact with the mercury film, but, on the other hand, are in the proper condition to be subjected to flotation. Accordingly, this method of combining amalgamation with flotation takes special advantage of the action of centrifugal force so that the amount of grinding necessary is reduced to a minimum, since the material to be ground is actually passed into the separation process just as soon as a proper degree of fineness in grinding has been attained. This process may also be carried out continuously, as before described. The mercury may be discharged from time to time by operation of the valves 57 and a new charge supplied so that the continuity of the operation may not be interrupted.

It will be noted that, in accordance with this method, the concentrates are progressively removed from the bath as soon as the proper degree of fineness has been attained. Accordingly, grinding to unnecessary fineness is avoided. It will be obvious, therefore, that, as valuable material is often lost in a process of this kind when the material is ground too fine, the present method obviates such loss and saves not only time and energy but also valuable material.

This method lends itself also to improvements in simple grinding operations without flotation. When grinding materials to a certain degree of fineness, the same may be passed into suspension in the liquid. When so sustained, the finer particles will tend to rise to the upper portions of the bath. By skimming the liquid from the upper part of the bath, this finer portion of the material may be progressively removed while the coarser particles remain in the bath for further grinding. It is thus possible to regulate the degree of fineness of grinding by regulating the height of the skimming edge or rim.

It is obvious that various changes may be made in the details of the method or apparatus within the scope of the appended claims without departing from the spirit of this invention; it is to be understood, therefore, that this invention is not limited to the specific details shown and described.

Having thus described the invention, what is claimed is:

1. The method of separating materials, comprising, floating the concentrates by froth flotation on a rotating bath, removing the floating material from the outer portion of the bath, and removing the gangue liquid from the inner portion at the top of the bath.

2. The method of separating materials, comprising, floating the concentrates by froth flotation on a rotating bath, removing the floating material from the outer portion of the bath, and simultaneously removing the gangue liquid from the inner portion at the top of the bath.

3. The method of treating materials, comprising, immersing the material in a rotating bath, centrifugally separating a heavier portion of the material from a lighter portion thereof within the bath, removing heavier portion by amalgamation, and removing said lighter portion by froth flotation.

4. An apparatus of the character described, comprising, a grinding bed, a muller co-operating therewith for grinding material, and means for carrying air and a reagent directly to the active grinding face.

5. An apparatus of the character described, comprising, a grinding bed, a muller co-operating therewith for grinding material, a liquid bath in which said bed is immersed, a shaft for said muller having a passage therethrough opening to the active grinding face of said muller, and means in said passage for separately supplying a reagent other than the liquid of the bath to said face.

6. An apparatus of the character described comprising, a liquid bath having therein a grinding bed, a muller co-operating therewith for grinding material, means for feeding material to said bed, and a reagent duct extending from outside the liquid bath adapted to carry a reagent through the bath to the active grinding face of said muller.

7. An apparatus of the character described, comprising, a liquid bath having therein a grinding bed, a muller co-operating therewith for grinding material, and means for supplying air and a reagent to the active grinding region.

8. An apparatus of the character described, comprising, means providing a rotatable liquid bath, means for feeding material to said bath to float thereon, a central shaft on which said bath rotates having an air passage therein, and a nozzle at the exit of said passage adapted to direct air on the floating material.

9. In a machine of the character described, a pan mounted for rotation on an axis, internal and external rims for said pan at nearly the same level adapted to provide spillways and means for rotating said pan at such a speed as to maintain the surface of the bath nearly level, whereby froth on the bath may be spilled over said external rim while liquid is spilled over said internal rim.

10. In a machine of the character described, a pan mounted for rotation on an axis, a rim for said pan adapted to provide a spillway for liquid contained therein, and a guard for said spillway adapted to permit only liquid drawn from below the surface of the liquid in said pan to pass over said spillway.

11. In a machine of the character described, a pan mounted for rotation on an axis, a rim for said pan adapted to provide a spillway for liquid contained therein, and a guard for said spillway adapted to permit only liquid drawn from below the surface of the liquid in said pan to pass over said spillway, said guard providing a spillway for the top-surface liquid.

12. In a machine of the character described, a pan mounted for rotation on an axis, and an external rim for said pan provided with a guard constructed and arranged for drawing liquid simultaneously from the top surface and a lower stratum of the liquid in said pan and a plurality of outer annular compartments on said pan adapted to receive such drawings separately.

13. The method of treating materials, comprising, feeding material to a liquid bath, maintaining the surface of the bath substantially level,

grinding the material in the same bath, floating the material by froth flotation on the surface of the same bath, and removing the froth over the rim of the bath.

14. The method of treating materials, comprising, feeding material to a liquid bath, maintaining the surface of the bath substantially level, grinding the material in the same bath, floating the material by froth flotation on the surface of the same bath, and blowing the froth from the surface of the bath.

15. The method of treating materials, comprising, feeding coarse material to a liquid bath, rotating the bath at such a speed as to maintain the surface thereof nearly level, grinding the material in the same bath, floating certain of the ground material by froth flotation on the surface of the same bath, and moving the froth from the surface of the bath by the centrifugal force of its own rotation.

16. The method of treating materials, comprising, feeding coarse material and a dry frothing reagent to a liquid bath, rotating the bath at such a speed as to maintain the surface thereof nearly level, grinding the material together with the frothing reagent in the same bath, floating certain of the ground material by froth flotation on the surface of the same bath, and moving the froth from the surface of the bath by the centrifugal force of its own rotation.

17. The method of treating materials, comprising, feeding material to a liquid bath, rotating the bath at such a speed as to maintain the surface thereof nearly level, floating certain of the material by froth flotation on the surface of the same bath, moving the froth from the surface of the bath by the centrifugal force of its own rotation, and removing the liquid from the inner portion of the top of the bath.

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