F. E. MARCY.

BALL MILL.

APPLICATION FILED SEPT. 4, 1913. RENEWED MAR. 3, 1915.

1,137,878.

Patented May 4, 1915.

3 SHEETS—SHEET 1.

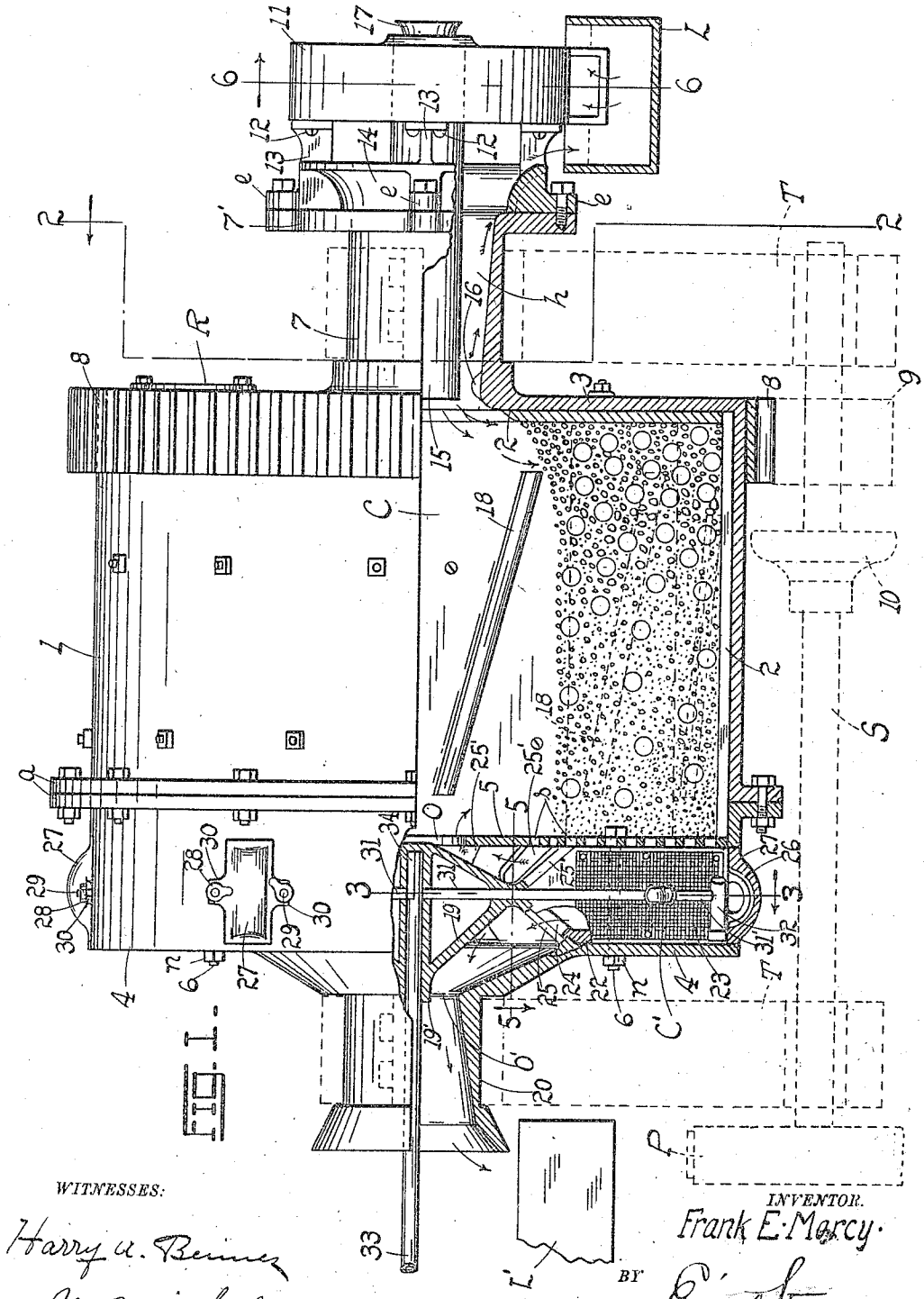


FIG. 1.

WITNESSES:

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3 SHEETS—SHEET 2.

FIG. 2.

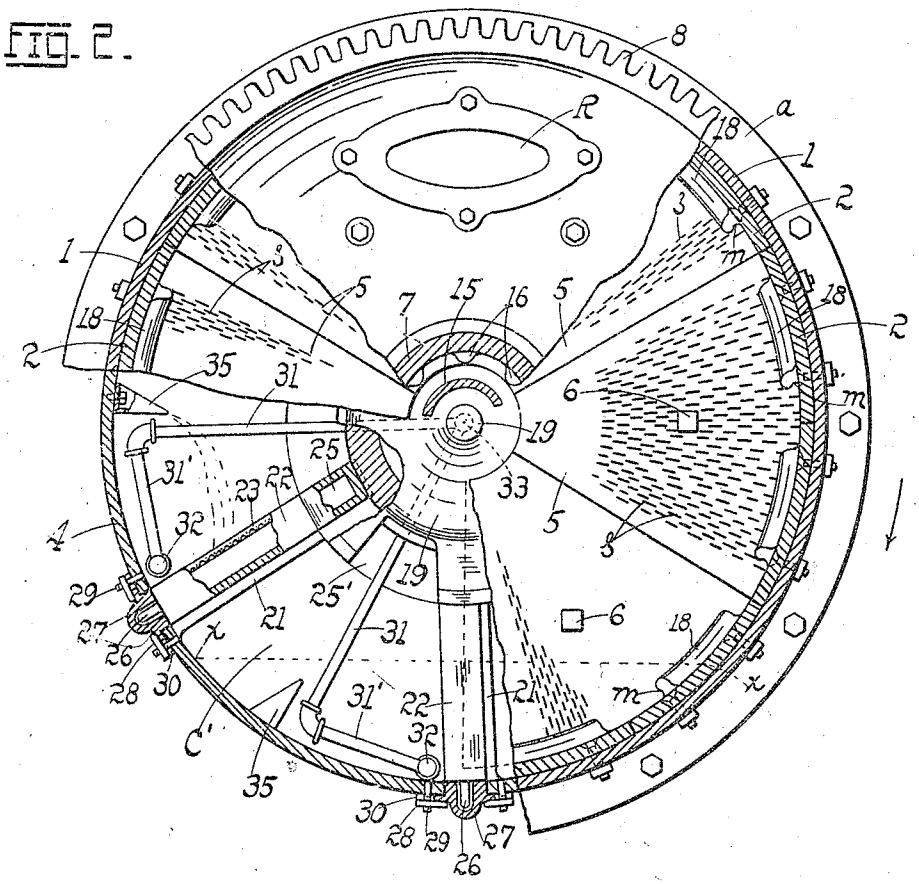
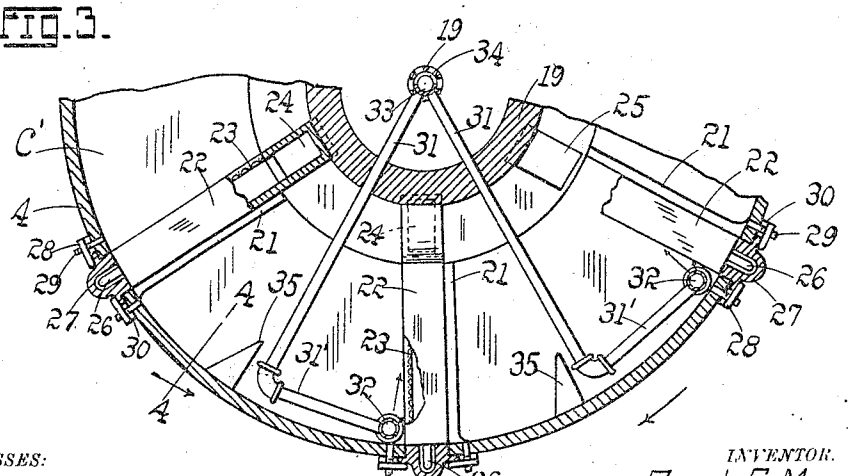


FIG. 3.



WITNESSES:

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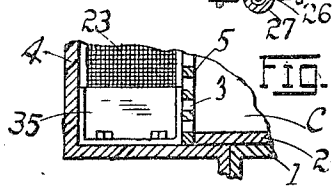


FIG. 4.

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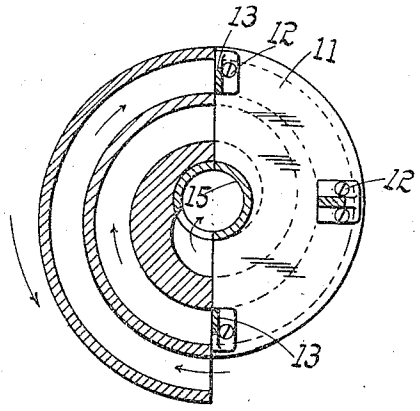
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3 SHEETS—SHEET 3.

FIG. 6



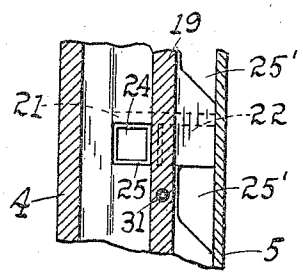


FIG. 5.

FIG. 7.

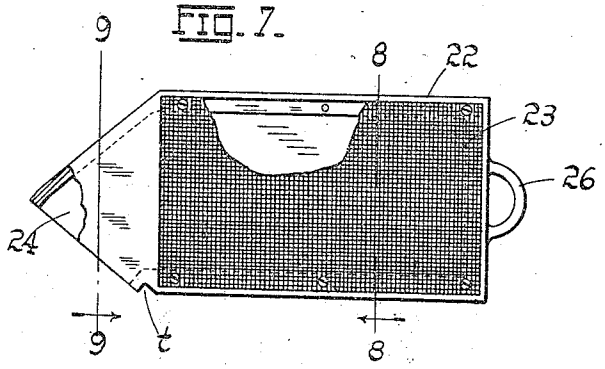
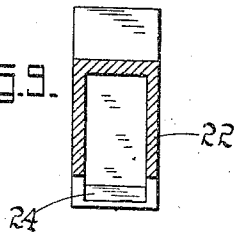


FIG. 9.



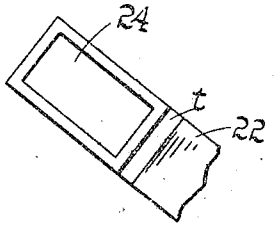


FIG. 10.

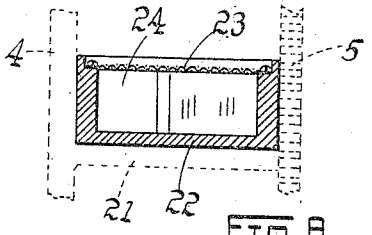
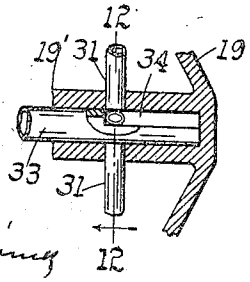


FIG. 8.

FIG. 11.



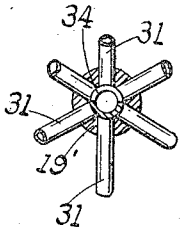


FIG. 12.

WITNESSES:

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UNITED STATES PATENT OFFICE.

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BALL-MILL.

1,137,878. Specification of Letters Patent. Patented May 4, 1915.

Application filed September 4, 1913, Serial No. 786,132. Renewed March 3, 1915. Serial No. 11,379.

To all whom it may concern:

Be it known that I, FRANK E. MARCY, citizen of the United States, residing at Salt Lake City, in the county of Salt Lake and State of Utah, have invented certain new and useful Improvements in Ball-Mills, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part hereof.

My invention has relation to improvements in ball mills; and it consists in the novel features of construction more fully set forth in the specification and pointed out in the claims.

In the drawings, Figure 1 is a combined side elevation and longitudinal vertical middle section taken through the mill; Fig. 2 is in part a vertical cross-section on the line 2—2 of Fig. 1, and in part an elevation of the inner component parts of the mill, said components being successively broken away in parts to expose those immediately behind them; Fig. 3 is a cross-sectional detail on the line 3—3 of Fig. 1; Fig. 4 is a sectional detail on the line 4—4 of Fig. 3; Fig. 5 is a sectional detail on the line 5—5 of Fig. 1 taken through the spider identified with the discharge trunnion of the mill; Fig. 6 is in part a cross-section on the line 6—6 of Fig. 1, and part an inner face view of the snail feed with the securing lugs in cross-section; Fig. 7 is a top plan of one of the boxes carrying the radial finishing screen; Fig. 8 is a cross-section on the line 8—8 of Fig. 7; Fig. 9 is a cross-section on the line 9—9 of Fig. 7; Fig. 10 is a face view of the open end of the screen-box; Fig. 11 is a sectional detail of the central sleeve or socket of the spider carried by the discharge head of the mill showing the inner notch on the water-supply pipe, and spray pipes radiating from the socket; and Fig. 12 is a cross-section on the line 12—12 of Fig. 11.

The present invention is an improvement on the construction of ball-mill forming the subject-matter of my pending application, Serial Number 750,893, filed February 26, 1913; and while contemplating the several objects and possessing the various advantages of the structure of said pending application, the present mill is designed to pass only minimum sized particles, the crushed material being so screened as to cause a return of any coarser particles back to the crushing chamber. The improved mill, however, is characterized by a number of structural features each of which possesses inherent advantages tending toward an ultimate high efficiency and increased capacity for the mill, said features being substantially as follows:—The mill is provided with two sets of screens, to-wit:—a diaphragm screen, and a series of radial finishing screens; means for facilitating the insertion and removal of the finishing screens; a special set of lifters for advancing the material from the intake end toward the discharge end of the crushing compartment; special means for preventing an overfeed to the mill; means for preventing an undue accumulation of fines at the outer corners of the finishing screens; means for preventing clogging or "blinding" of the screens; means for spraying or washing the finishing screens; and in other features of construction the advantages of which will be fully apparent from a detailed description of the invention which is as follows:—

Referring to the drawings, 1 represents a cylindrical (preferably cast iron) container, drum or tumbling barrel (or equivalent tubular member) provided with a lining of silex, hard gray iron, steel, or equivalent layer 2, said lining being confined to the walls of the barrel and to the head 3 at the intake end of the barrel, the opposite head 4 not necessarily requiring a lining. The lining is made up of a convenient number of removable sections bolted to the shell and head as shown.

For convenience, the present barrel is cast in two sections bolted together along the flanges *a*, *a*, the larger section being identified with the crushing compartment C, and the smaller section with the sizing or screening compartment C′, the two compartments being separated by a transversely disposed primary or diaphragm screen 5 (of manganese steel) composed of a number of sections, each section being secured to the head 4 (identified with the smaller of the two sections of the barrel) by a bolt 6 (with the nut *n* on the outside of the mill) spanning the compartment C′. The screen 5 is provided with radially disposed slots *s* extending over the outer and major portion thereof, the slots being approximately $\frac{1}{8}$″ wide and one inch long and allowing the feed or pulp to enter the sizing compartment C′.

The intake for the feed or pulp is through the hollow trunnion 7 of the head 3, the barrel rotating clockwise, that is to say, the bottom of the barrel turning toward the observer (Fig. 1). Any suitable mechanism may be employed for imparting rotation to the barrel, that here shown being a gear ring 8 on the larger section meshing with the pinion 9 on a shaft S driven by a belt-pulley P leading to any source of power (not shown), a clutch 10 being employed to couple the shaft to, and uncouple the same from, the gear 8. The driving elements and the supporting standards T for the mill are shown dotted because well understood in the art and familiar to every skilled mechanic.

In the present embodiment of my invention the pulp (or mixture of ore crushed to ¼″ size mixed with water) is fed from a launder L by means of a snail-shell feeder 11 of conventional design, the feeder in the present case having secured thereto (by means of screws 12 passed through lugs 13), a bell-shaped or outwardly flaring lip or ring 14, which in turn is bolted to the flange 7′ of the hollow trunnion 7 through the bosses *e*, the latter together with the lugs 13 being cast with the ring. In this way the feeder 11 is directly secured to the trunnion 7, and is caused to rotate about the axis of the trunnion and of the mill when rotation is imparted to the latter. Leading from the feeder is a discharge pipe 15 spaced from the inner inwardly converging or tapering walls of the trunnion 7, the inner end of the trunnion passage being provided with a series of circularly disposed knobs 16 to prevent the material from coming out of the mill when the latter is in operation, the knobs or their equivalents being specially desirable with a pipe-discharge such as 15. The annular (or rather conical) space or passage-way *h* between the pipe 15 and the inner wall of the trunnion 7 constitutes an outlet for any over-feed, any excess of material over and above what the mill can conveniently handle running back through said space and over the lip or ring 14 into the launder L (see feathered arrows Fig. 1). The feeder is provided herein with a removable plug 17 which can be taken out during the operation, and by the use of a lamp placed opposite the opening, the action of the balls and pebbles and condition of the material inside of the mill can be readily seen.

As well understood in the art, the inner walls of the shell are provided with series of projections or lifters 18 set at a diagonal, or at an incline to the axis of rotation of the mill, said lifters preventing the ore and pebbles which hug said walls from slipping. In the present embodiment of my invention the lifters are preferably cast to the liner sections (though they may be otherwise secured), and are provided with opposite concave and convex faces, the concave faces forming channels or grooves *m*, which dip toward the discharge end of the mill during the upward sweep of the lifters, that is to say for substantially one-half of a complete revolution of the mill, said grooves dipping in the opposite direction with the downward sweep of the lifters for the other half revolution of the mill, such operation necessarily resulting by reason of the inclined disposition of the lifters (Fig. 2). The mill or barrel rotating as before stated, clockwise, it follows that the concave faces or grooves *m* will face downward as they approach the bottom of a rotation, and will face upward when describing their upward sweep. Since in such upward sweep they dip toward the discharge end, it follows that the lifters or rather the channels or grooves *m* thereof will cause any fluent material picked up by them to flow or migrate toward the screen 5 (and hence toward the discharge end of the mill), said migration being in the general direction of migration or flow of the material entering the mill through the feed-pipe 15.

The screen 5 is disk-shaped, being provided with a central opening or passage O (the slots *s* terminating a suitable distance from the opening) which establishes communication between the compartments C, C′. The compartment C′ is disposed between the screen 5, and head 4, and between the shell of the barrel and the central casting or spider 19 forming an integral part of said head. Between the inner end of the discharge trunnion 20 cast with the head 4, and the outer terminal of the central tubular portion 19′ of the casting 19 is an annular discharge opening O′ through which the finished product finds its way into the trunnion 20, and from the latter to any suitable launder or vessel L′.

Disposed radially across the sizing compartment C′, and cast with the head 4 are a series of platforms or radial lifters 21 each of which serves to support the bottom of a box 22 whose upper wall is composed of a fine mesh or finishing screen 23, set in a marginal offset, groove or depression in the walls of the box and secured by screws (Fig. 7). The terminal inner portions of the side walls of the box taper inwardly so as to conform and snugly engage the converging walls forming the periphery of the spider 19 (and constituting the inner bounding wall of the compartment C′), the tapering side of the box adjacent the head 4 being left uncovered thereby leaving a discharge opening 24 which registers with a discharge opening 25 of the spider, said openings being disposed on the inclined peripheral wall of the spider adjacent the head 4 and serving to conduct the finished product to the an-

nular passage O' whence it escapes through the hollow trunnion 20 into the launder L'. To insure a stable engagement between the boxes 22 and the wall of the spider in which the openings 25 are formed, each box is provided with an offset or shoulder *t* (Fig. 7) at the base of the inclined end identified with the opening 24, said shoulder engaging the outer terminal wall of the opening 25, the latter thus forming as it were, a socket for the discharge end of the box and preventing displacement thereof when once inserted into place. As shown in the drawings, a box 22 is inserted into the compartment C' between the head 4 and the diaphragm screen 5, the inner side of the box preferably overlapping the seam between two sections of the diaphragm screen (Fig. 2). To facilitate insertion and removal of a box, the outer end wall of the latter is provided with a handle 26 normally projecting beyond the shell of the barrel and protected by a hood or cover plate 27 which covers the hand-hole through which the box is inserted, there being one hand-hole for each box. The hood is preferably secured by a pair of lever-nuts 28 passed over screw-stems 29 on the shell, the hood being provided with lugs or ears 30 spanning the screw, the nut being screwed against the ears, thereby clamping the hood to the shell. The hood is made bonnet-shaped as shown to span and protect the handle 26 of the box.

Disposed on the inclined peripheral wall of the spider 19 adjacent the screen 5, and alternating with or arranged circularly in staggered relation to, the openings 25, are openings 25' designed to return back to the crushing compartment any oversize or material too coarse to pass through the meshes of the screen 23 into the box 22. These openings 25' communicate with the crushing compartment C through the central passage O of the diaphragm screen 5, (Fig. 1), the surfaces of the screens 23 being substantially flush with what might be considered the bottoms of said openings (25') in contradistinction to a similar relation between the boxes 22 and openings 25, the bottoms of the boxes being flush with the bottoms of the openings 25. In other words, as the mill revolves about its axis, the finished product runs out of the boxes 22 into the openings 25 and out, the coarse product or oversize running along the radial screens into the openings 25' back into the mill.

To facilitate the screening, and the return of the oversize back into the mill, resort is had to a series of radially-disposed spray-pipes 31, having outer portions or extensions 31' coupled thereto, substantially at right angles to the pipes 31, the extensions being provided with spray-heads or branches 32 disposed parallel to the surfaces of the screens 23, and parallel to the axis of rotation of the mill. The pipes 31 lead from the walls of the inner socket 19' of the spider 19 (said socket having a closed bottom as shown) and pass through suitable openings provided therefor in the spider, there being a spray-pipe (and head) for each finishing-screen. Entering axially through the discharge trunnion 20 is a fixed or stationary water-supply pipe 33 which terminates in the socket 19' opposite the intake ends of the spray-pipes, the end of the pipe in the socket having a section of its upper peripheral wall removed so as to leave a notch 34, said notch permitting a peripheral discharge of the water from the pipe 33 to at least three of the spray-pipes as the inner intake ends thereof come opposite the notch in their revolution (with the socket 19' which virtually forms a sleeve about the pipe 33) about the axis of the feed-pipe. The wash water is thus automatically (and successively) admitted to the upper set of spray heads 32, that is to say to the spray-heads of the radial pipes 31 whose intake ends are in position to receive the water delivered through the notch 34 of the feed-pipe. The object of this arrangement must be apparent, as necessarily the screens 23 are sprayed or washed as they approach the top of the mill and after they have gathered up their charge, the wash water assisting the screening and likewise carrying the oversize or coarse material down the screens toward the axis of the barrel and toward the openings 25' through which the oversize is returned to the crushing compartment.

To prevent an accumulation of material at the outer corners of the screens 23 (that is at the corners between the screens and inner wall of the shell of the barrel) I provide the shell with a series of buckets or scoops 35, which scoop up the material as the mill revolves through the water and pulp, and then subsequently dump it onto the screens below. Without the buckets, much material would tend to collect in the corner of the screen next the periphery, such accumulation being undesirable; with the buckets placed in front of the several screens this objection is eliminated. The head 3 is provided with a man-hole closed by a cover plate R for an obvious purpose. Features shown but not alluded to are well understood in the art and require no description in the present connection. I do not of course, intend to restrict myself to the details here shown as they may be departed from without affecting the nature of the invention.

The operation of the mill is substantially as follows:—The feed or pulp is delivered from the crushers or rollers to the launder L, say $\frac{1}{4}$'' size mixed with water, rotation being imparted to the mill or barrel clock-

wise as already pointed out. As the barrel rotates, the feeder 11 (coupled thereto) scoops up the material from the launder and discharges it through the tube or pipe 15 into the crushing compartment C, the latter being filled about one-third with steel balls or flint pebbles as well understood in the art, the water level being kept down by the action of the radial lifters in the compartment C′, to a plane approximating the dotted line X—X in Fig. 2. With the water level kept down as represented, the buoyancy of the pebbles or balls by the water is overcome, thus resulting in a considerable increase in the capacity of the mill. With the water level in the mill kept down as indicated, when the pulp (ore and water) enters the mill through the trunnion 7 as described (or more properly through the pipe 15), the water carrying the ore tends to rush through the mill rapidly under the head which delivers it, thus causing the fines to migrate toward the diaphragm screen 5 and the discharge end of the mill. This action, coupled with the action of the longitudinal lifters 18 as previously described tends to cause a rapid migration of the fines in the desired direction through the mill. With the barrel's rotation the ore tends of course to hug the peripheral walls of the barrel, and in the general migration of the fines the ground material passes through the radial slots *s* of the diaphragm-screen into the sizing compartment C′. As it enters this compartment the material flows over the finishing screens 23, that portion (or undersize) which is fine enough to pass through said screens dropping on the radial lifters or bottoms of the boxes 22, and in the course of the rotation of the barrel flowing "down" the lifters through the openings 24, 25, to the passage-way O′ into and through the discharge trunnion 20 into the launder L′. The portion or oversize which is too coarse to pass through the radial screens flows "down" the screens into and through the discharge openings 25′ and opening O back into the crushing compartment C. As previously stated, this final screening and sizing is facilitated by the jets from the spray-heads 32, which flush the surfaces of the screens 23 when the latter occupy the upper portion of the barrel, that is to say, when they have rotated to points above a horizontal plane and dip downward toward the axis of the barrel. The action of the screens 23 and their radial lifters may be compared to that of a series of flat spokes along which the material runs downward toward the hub of the wheel of which such spokes form a part. In my improvement these "spokes" are removable through the periphery of the barrel or drum 1. As the barrel revolves any material picked up by the buckets 35 will be automatically dumped onto the screens 23, where it takes the course already outlined.

A mill of the type here described delivers a product composed of minimum sized particles uniform in dimensions and eminently adapted for concentration or any subsequent treatments known to the art; it has a maximum capacity, is simple in construction, may be readily repaired, and the first cost is small. It is susceptible of modification in many details without necessitating a departure from the nature or spirit of the invention. The interior of the mill is readily accessible so that a repair may be quickly made. Should there be any over-feed of the mill the excess of the material will run back into the launder L through the trunnion 7, so that the operator is given ample warning, and he can accordingly reduce the feed coming from the original supply source.

It may be stated in passing that apart from the support which the platform or lifter 21 affords to the box 22, it has no different function from that of the bottom of the box supported by it. That is to say, it serves the purpose of a radial lifter, although the immediate lifting of the finished product is done by the box-bottom. Were the boxes supported in some other manner the members 21 could be dispensed with and we should still have a combination of an imperforate lifter (the bottom of the box) with a radial screen acting in conjunction therewith. So far as the claims are concerned therefore, it is immaterial (except where a specific distinction is made) which member we consider as the radial lifter; either or both may be so regarded (that is to say, the member 21 or the bottom of the box 22).

Having described my invention, what I claim is:—

1. In combination with a tumbling-barrel or container rotatable about an axis and provided with intake and discharge openings, a diaphragm screen disposed across the rotation axis adjacent the discharge end of the barrel, means in the barrel for effecting a migration of the fines toward said diaphragm, radially disposed screens between said diaphragm and discharge opening operating to screen the fines and direct the same toward the discharge opening and to direct the oversize back to the barrel, and means on the walls of the barrel for preventing an accumulation of fines in the outer corners of the radial screens.

2. In combination with a tumbling barrel provided with peripheral openings and rotatable about a fixed axis, and having intake and discharge means, removable screens radiating from said axis and insertible into the barrel through said openings.

3. In combination with a tumbling-barrel

or container rotatable about an axis and provided with intake and discharge means, a primary screen in the barrel located near the discharge end but spaced therefrom, secondary or finishing screens in said space removable through the peripheral walls of the barrel and operating to deliver the fines or undersize to the discharge means, and means operating in conjunction with said secondary screens to return the oversize back to the barrel.

4. In combination with a tumbling-barrel rotatable about a fixed axis, and provided with crushing and sizing compartments, a screen disposed across the rotation axis and forming a division wall between the compartments, and radially disposed finishing screens in the sizing compartment insertible thereinto through the peripheral walls of the barrel.

5. In combination with a tumbling-barrel rotatable about a fixed axis, and provided with a crushing and sizing compartment and with peripheral openings, a screen disposed across the rotation axis between the compartments, radially disposed finishing screens in the sizing compartment insertible thereinto through the peripheral openings aforesaid, and radial imperforate members operating in conjunction with the finishing screens for conducting the fines out of the barrel.

6. In combination with a rotatable tumbling-barrel having a sizing compartment provided with a discharge opening disposed about the axis of rotation of the barrel, radially disposed sizing screens in said compartment, a central member provided with a socket disposed about the axis of the discharge opening, a water feed-pipe entering said socket and provided with peripheral discharge means within the socket, spray-pipes leading from the socket and adapted to be brought into coöperation with said discharge means in the course of rotation of the barrel, and means for conducting the water from the spray-pipes to the sizing screens.

7. In combination with a tumbling-barrel rotatable about a fixed axis and provided with intake and discharge means disposed about said axis, a sizing compartment communicating with the discharge means, a member having a peripheral surface forming the inner boundary of said compartment, radial sizing screens and lifters supporting the same disposed in said compartment about the periphery of said member, the peripheral walls of the latter being provided with openings circularly staggered about the rotation axis and communicating respectively with the lifters and screens aforesaid, and discharging respectively into the discharge means and into the barrel.

8. In combination with a tumbling-barrel rotatable about a fixed axis and provided with a crushing compartment, and a sizing compartment having discharge means out of the barrel and into the crushing compartment respectively, a series of radial lifters and screens insertible conjointly through openings in the barrel wall into the sizing compartment and discharging through the discharge means of the sizing compartment aforesaid out of the barrel and into the crushing compartment, and means for holding the said lifters and screens in place when once inserted.

9. In a rotatable tumbling barrel having a sizing compartment, a combination box and screen insertible thereinto through an opening in the wall of the barrel, a crushing compartment, and means for conducting the fines out of the box and out of the sizing compartment through the barrel wall, and returning the oversize from the screen to the crushing compartment.

10. In combination with a tumbling-barrel rotatable about a fixed axis and provided with a crushing compartment having an intake opening disposed about the rotation axis, and with a sizing compartment having a discharge opening disposed about the same axis, a screen disposed across the barrel and forming a division wall between the two compartments, radially disposed finishing screens and corresponding imperforate lifters inserted as a unit into the sizing compartment through the walls of the barrel and operating respectively to conduct the oversize back into the crushing compartment, and the fines out of the barrel through the discharge opening.

11. In a tumbling-barrel having a sizing compartment and rotatable about a fixed axis, a combination lifter and screen insertible into the compartment through the wall of the barrel, a handle at the outer end of the lifter, and a cover plate on the barrel wall, as set forth.

12. In a rotatable tumbling-barrel, a sizing compartment, and suitable radially disposed combination screens and imperforate lifters in said compartment, conjointly removable therefrom through the walls of the barrel, as set forth.

13. In combination with a tumbling-barrel rotatable about a fixed axis and provided with an axial discharge opening for the fines, a sizing compartment, a spider or member disposed about the rotation axis and carried by the barrel and forming the inner boundary of the sizing compartment, a series of radial screens and corresponding radial imperforate lifters disposed about the spider aforesaid, the latter being provided with a central socket, a water-feed pipe leading into said socket and discharging thereinto through an upper peripheral opening in said pipe, a series of spray pipes lead-

ing from the socket of the spider through the spider walls and rotatable therewith about the axis of the barrel, said spray-pipes operating to conduct the water out of the socket during a prescribed portion of a rotation of the barrel, and discharge the same onto the several screens, and means in cooperation with the radial lifters for conducting the fines out of the barrel through the discharge opening aforesaid.

14. In a rotatable tumbling-barrel having a hollow intake trunnion, and a series of knobs or formations at the inner end of the trunnion, and means in the trunnion for discharging the material to be treated, into the barrel.

15. In combination with a tumbling barrel provided with peripheral openings and rotatable about a fixed axis, and having intake and discharge means, removable lifters radiating from said axis and insertible into the barrel through said openings.

In testimony whereof I affix my signature, in presence of two witnesses.

FRANK E. MARCY.

Witnesses:
NEER SIMPSON,
GEO. P. SMITH.