Dec. 29, 1953 J. B. MARTIN 2,664,248

BALL MILL WITH FEED AND DISCHARGE MEANS AT EACH OPPOSITE END

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Fig. 1.

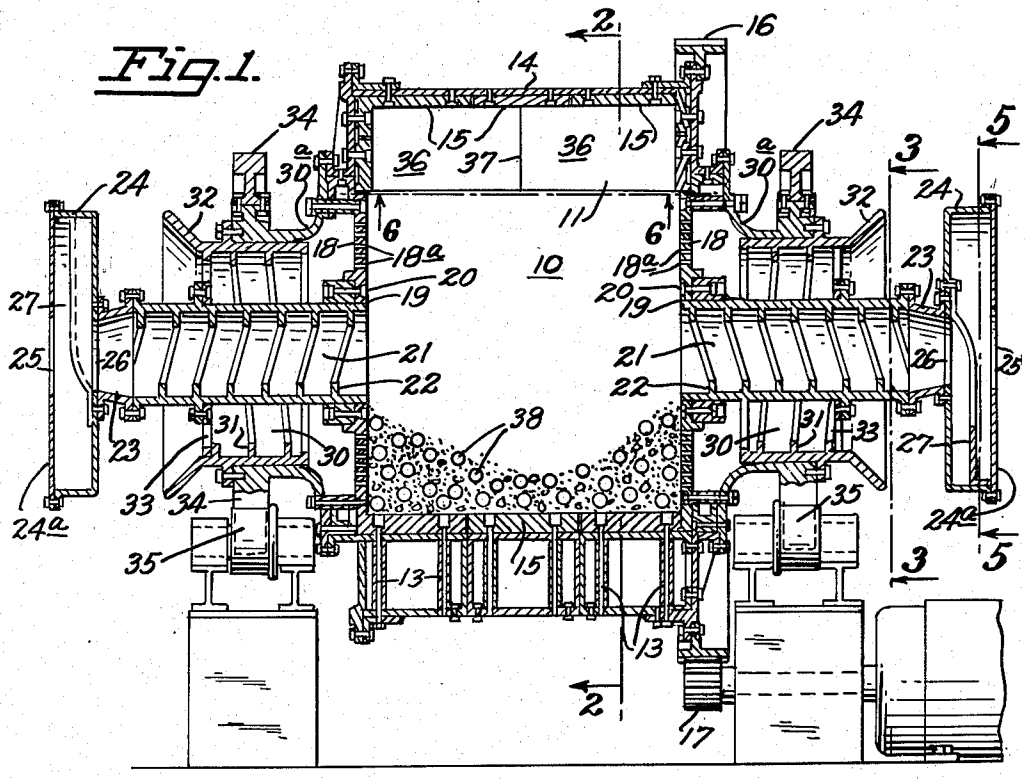



Fig. 2.

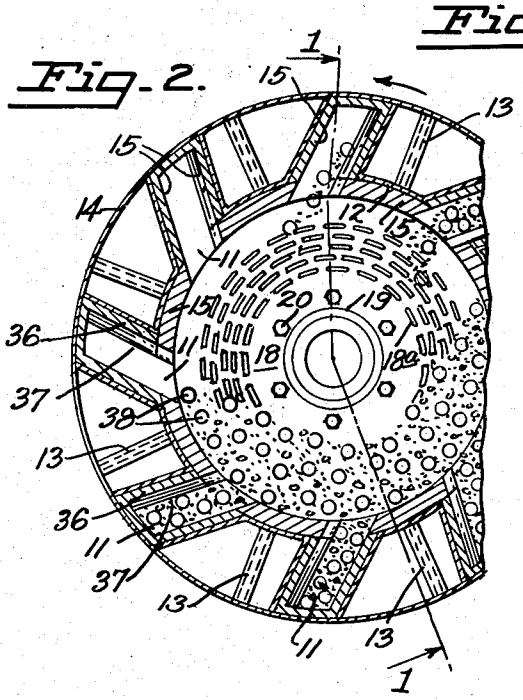
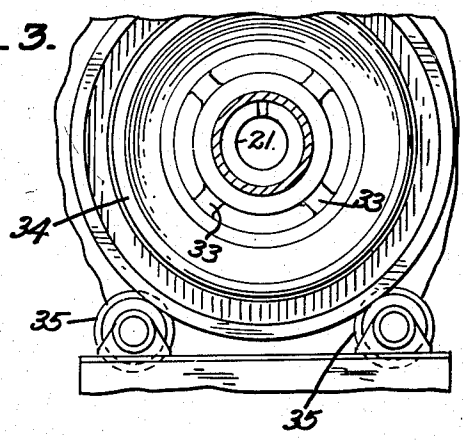



Fig. 3.




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Fig. 4.

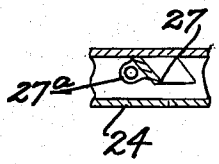
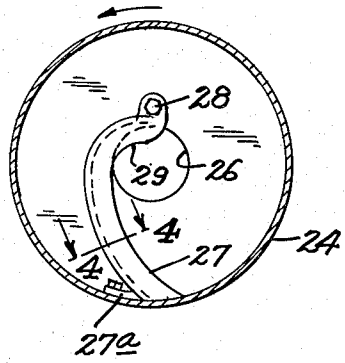



Fig. 5.



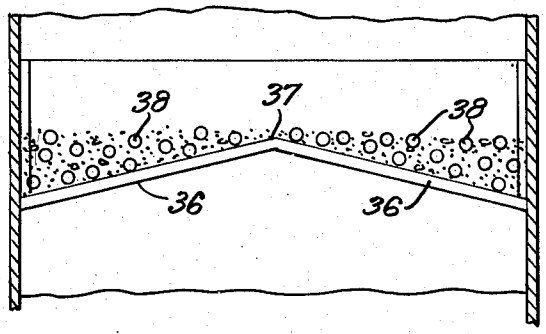




Fig. 6.

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## BALL MILL WITH FEED AND DISCHARGE MEANS AT EACH OPPOSITE END

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Application June 19, 1951, Serial No. 232,327

6 Claims. (Cl. 241—70)

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This invention relates to improvements in ball mills with feed and discharge means at opposite ends and more particularly relates to means for simultaneously feeding ore aggregate and discharging ground ore at each of the opposite ends of the mill.

The invention of this application has reference in certain mechanical respects to my co-pending application for a ball mill, Serial No. 790,509, now Patent No. 2,560,972, filed December 9, 1947 insofar as the grinding drum portion of the mill is concerned.

The improvement of this invention is in the feed and discharge means in ball mills, which comprises an axially disposed tubular helical conveyor feed member at each opposite end of the rotatable mill drum, a sifting screen in each end wall of the mill drum circumferentially of the tubular feed member and a tubular helical conveyor discharge member circumferentially enclosing each tubular feed member and spaced therefrom, the discharge conveyors communicating with the drum through the sifting screens at the opposite ends of the drum, means being also provided for automatically intermittently feeding ores into the mill continually responsive to rotation of the mill. In association with feed and discharge at opposite ends of the mill, there is preferably provided means to increase the grinding capacity of the mill adjacent the feed intake and discharge at the opposite ends of the mill.

The object of the invention is to double the feed and discharge capacity of a ball mill of the type of my said previous application, and to deposit the feed ore aggregate relatively close to the discharge orifices for the comminuted ore, so that the ore aggregate as it is fed into the mill and churned by the balls therein will maintain the comminuted ore agitated in proximity to discharge screens for such comminuted ore and thereby facilitate sifting and discharge more rapidly of the pulverized ores through the screens.

A further object of the invention is to provide simultaneously operative feed means and discharge means at each end of a ball mill continually intermittently operative by the rotation of the drum, and to increase the grinding capacity of the mill in proximity to the reception of the ore within the grinding compartment of the mill.

One form in which the invention may be exemplified is described herein and illustrated in the accompanying drawing, in which:

Fig. 1 is a central vertical section longitudinally of the mill axis, or line 1—1 of Fig. 2.

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Fig. 2 is a vertical transverse section on line 2—2 of Fig. 1, partly broken away.

Fig. 3 is a fragmentary vertical transverse section on line 3—3 of Fig. 1.

Fig. 4 is a fragmentary section on line 4—4 of Fig. 5.

Fig. 5 is a section on line 5—5 of Fig. 1.

Fig. 6 is a fragmentary front elevation of longitudinal opening of a bay member axially transversely of the drum of the mill, the latter being shown on lines 6—6 of Fig. 1.

Referring to the drawing in which like reference characters indicate corresponding parts in the several views, 10 indicates generally the rotatable drum portion of the ball mill which is mounted for rotation on a horizontal axis and which may be the standard conventional drum without appurtenant changes, or may have any suitable particulars of detailed structures modified from the standard conventional drum to facilitate operation of the novel feed and discharge means and the sifting screen means associated therewith, and such special features of the rotary drum may be especially adapted to function with such feed and discharge means. It is preferred that the drum portion of a mill be of the general type disclosed in my said copending application No. 790,509 with reference to which the drum of the present invention may be briefly described as having circumferentially spaced elongated bays 11 transversely between the end walls of the drum and extending radially outwardly from the outer circumference of the central hollow portion of the drum. The bays are inclined rearwardly relative to the direction of rotation of the drum and have one side opening into the drum portion.

The drum wall 12 between the opening of the bays provides the circumference of the hollow drum portion of the mill, said walls being supported by tie bolts 13 within an outer circumferential casing 14, the tie bolts 13 being in the spaces between the bays. Any suitable wear resisting liners 15 may be provided as inner facing for the walls of the drum and bays, preferably in replaceable sections as indicated in the drawing.

Rotation of the mill may be by any well known means such as the driven gear 16 meshing with drive pinion 17.

Each of the end walls of the drum comprises a perforated circular disc plate sifting screen 18 preferably of diameter of the central portion of the drum exclusive of the bays 11, whereby milled material may be discharged adjacent the circumference of said drum portion, the openings

or perforations 18a in the screen preferably being elongated in direction parallel to the circumference of the screen disc plate as best shown in Fig. 2. The sifting screen plates are coaxial with the mill and each plate has a central opening 19 in which is fixedly mounted, as by collar and bolts 20, one open end of a rotatable tubular helical conveyor feed member 21 having therein throughout its length a helical rib 22 the pitch of the rib being in direction towards the drum from the open receiving throat 23 at its opposite or free end.

Means are provided at the free open end of each helical feed conveyor to continually, automatically and intermittently supply ore aggregate thereto, comprising a rotary hopper 24 which is mounted at the free end of each of the helical feed conveyors and rotates therewith, each such hopper comprising a generally circular chamber member which is a reservoir for ore aggregate to be fed to the spiral conveyor. The rotary hopper reservoir chamber has a removable outer planar face 24a having an axial opening 25 centrally thereof through which a supply of ore aggregate may be fed, and having an axial opening 26 at its inner rear planar wall communicating with the helical conveyor 21 through receiving throat 23. Internally each rotary feed hopper is provided with a substantially radial fin or blade 27 secured at its outer end to the inner face of the circumferential wall of the hopper as at 27a and extending therefrom to a point beyond the axis of the feed opening 26 where it is secured at its said inner end to the rear planar wall of the hopper as at 28, the last mentioned or radially inner end of the blade being curved around the edge of the opening 26 as at 29. In transverse cross section through its body the blade is at an acute angle to the inner rear wall of the hopper so that it provides therewith a substantially V-shaped angle forming a groove, which, upon rotation of the blade, picks up ore at a downward position and feeds it by gravity through opening 26 upon rotation to an upward position. Thus the supplying of ore aggregate to the helical feed conveyor is automatic and continually intermittent.

Coaxially with and circumferentially of and spaced from each of the helical feed conveyors at opposite ends of the mill is a tubular discharge conveyor 31 having a helical rib 31 therein, pitched oppositely relatively to the pitch of the rib of the feed conveyor, though the incline of pitch of rib in the discharge conveyor may be less than in the feed conveyor, due to its greater conveying surface. At its inner end which is securely connected to the end wall of the drum, the discharge conveyor communicates with the drum through the openings 18a of the adjacent screen 18, for which purpose the connected end of the conveyor is flared radially outwardly to substantially equal the diameter of the screen and drum portion exclusive of the bays, as at 30a to encompass and communicate with a screen of larger diameter than is necessary for the tubular helical portion of the conveyor. At its opposite or open end the discharge conveyor may be provided with a discharge bell 32 from which the discharged comminuted ore may be delivered into any suitable receiving bin or tray (not shown). One or more spiders 33 support the feed conveyor and discharge conveyor in relatively spaced relation.

Since the feed conveyors at the opposite ends of the mill are to convey ore aggregate into the drum and the discharge conveyors at said opposite ends convey ground ore material away from the drum, it is obvious that the respective opposite feed and discharge conveyors will have helical ribs oppositely pitched relatively.

It is also to be observed that due to the fixed connection of the rotatable drum and bays, the sifting screen and the conveyors, the rotation thereof is in unison.

Any suitable means may be provided for supporting the mill rotatively and as herein exemplified comprises tracks 34 adjacent opposite ends of the mill, preferably mounted circumferentially of the discharge conveyors 30 and riding upon the usual relatively spaced rollers 35.

With reference to special structural adaptation of the rotary drum and bays to cooperate with the combined feed and discharge means at each of the opposite ends of the drum, it is to be observed that the greater percent of the ore aggregate in the drum at any one time will be most nearly adjacent the feed inlets, though it will also be spread across the drum in lesser degree toward the center, as indicated by stipling in Fig. 1. The areas adjacent the screens also should be cleared of comminuted ore as rapidly as the ore becomes sufficiently ground, so that the ground ore near to the screen will not obstruct movement of ground ore from the central portion of the mill towards such screen, and also in order that accumulated ground ore will not act as a shock-absorbing pad to the impact of the cascading and mulling of the balls in the mill. Therefore it is preferred that provision be made for a differential of cascading balls adjacent the feed inlets at the opposite ends of the mill. Since the balls in the lower portion of the drum will, by mulling, seek a substantially uniform depth level, the differential is provided by structurally designing the bays so that the balls lifted by the bays are arranged in the bays with a greater portion of the balls at the opposite end portions of the bays where, when they are thrown or cascaded from the bays, the greater quantity of the balls will impact upon the balls and ore adjacent the opposite end of the drum adjacent the inlet of the feed means. A simple rugged structure to accomplish this result is provided by upwardly crowning the transverse width of the follower wall 36 of the bays at its longitudinal central portion as at 37 so that the width of opening and the volume capacity of the bays is greater at the opposite end portions than at the central portion thereof, providing a pocket at each opposite end of the bays, and whereby, when the follower wall is ascending by rotation of the drum, the follower wall (which is then the bottom wall of the bay) will incline downwardly or rearwardly (relative to direction of rotation) from its central portion towards its opposite ends as shown in Fig. 6, and the balls in the bays will thereby roll in greater quantity from the central portion toward the opposite end pockets and thereby increase the quantity of discharge of balls from the bays adjacent the ends of the mill and into the zone of the fed ore adjacent the feed inlets at the opposite ends of the drum. This additional pounding of the greater quantity of ore at said ends of the drum creates a larger quantity of comminuted ore closely adjacent the discharge screens which sift through the screens with facility without the necessity of the ground particles working their way by creeping through a large body of mixed ore and balls from the

central portion of the drum towards the discharge screens.

In operation, ore aggregate is fed at each end of the mill into the hoppers 24 through the openings 25 whereupon it is picked up continually intermittently in relatively small batches as the blades 27 rotate and is delivered automatically to the helical feed conveyor 21, one great advantage of this type of feed means being that by merely removing the face plates 24a the size of radial plate 27 may be changed for various types of ore so that the entire grinding capacity of the mill may be always employed, that is, for the more slowly pulverized hard ore a smaller feed blade 27 may be employed, whereas for a more quickly pulverized softer ore a larger feed blade 27 may be employed, and thus by a comparatively simple and easily effected adjustment the entire grinding capacity of the mill is available for ores of varying degrees of hardness.

Ore aggregate having been delivered to the helical feed conveyors 21 it is carried into both ends of the drum simultaneously and there comminuted by pounding and mulling by the balls 38 in the drum, which latter operation is greatly facilitated and expedited if the mill is provided with radiating bays 11 which carry a portion of the balls beyond normal position of elevation before cascading them to the mass body of ore and balls in the lower portion of the drum. The two bodies of ore fed into the opposite ends of the drum are constantly opposing each other and this facilitates and expedites the discharge of comminuted ore which works its way out through the sifting screens 18, at both the opposite ends of the drum, and is picked up by the helical discharge conveyors and discharged to any suitable bin at the bell end of the discharge conveyors.

If the crowned follower wall is employed in the bays to increase pounding, grinding and discharge at the end portions of the mill, the operation thereof has been set forth in connection with the description of structure of such crowned walls in the bays, but it is to be further noted that such increased pounding by cascading the increased volume of balls adjacent the opposite ends of the mill closely to the discharge sifting screens also has the effect of increasing the vibration of the balls and ore closely to the screens and thereby increases the discharge by vibrating the comminuted particles through the screen more rapidly.

Having described the invention, what is claimed as new and patentable is:

1. In a ball mill, a rotatable drum for receiving balls and ore aggregate, said drum being mounted for rotation on its horizontal axis, axially longitudinally disposed bays which are substantially the axial width of the drum and extend in circumferentially spaced relation radially outwardly from the outer circumference of the drum, and inclined rearwardly relative to direction of rotation of the drum, each bay having one of its longitudinal sides opening into the drum, and a feed means and a discharge means mounted at each of the opposite ends of the drum, and a sifting screen at each opposite end of the drum, the said discharge means at each end of the drum communicating with the drum through the screen.

2. In a ball mill, a rotatable drum for receiving balls and ore aggregate, said drum being mounted for rotation on its horizontal axis, axially longitudinally disposed bays which are substantially the axial width of the drum and extend in circumferentially spaced relation radially outwardly from the outer circumference of the drum and inclined rearwardly relative to direction of rotation of the drum, each bay having one of its longitudinal sides opening into the drum, and a coaxial feed and discharge means mounted one within the other at each of the opposite ends of the drum and rotatable therewith, and a sifting screen at each of the opposite ends of the drum, the said discharge means at each end of the drum communicating with the drum through the screen.

3. In a ball mill, a rotatable drum for receiving balls and ore aggregate, said drum being mounted for rotation on its horizontal axis, axially longitudinally disposed bays which are substantially the axial width of the drum and extend in circumferentially spaced relation radially outwardly from the outer circumference of the drum and inclined rearwardly relative to the direction of rotation of the drum, each bay having one of its longitudinal sides opening into the drum, and a feed and discharge means mounted at each of the opposite ends of the drum and rotatable therewith, said feed and discharge means at each end of the drum including a disc plate sifting screen in each end wall of the drum and having a central opening therethrough, a tubular helical feed conveyor having one end communicating with the drum through said central opening, and a tubular helical discharge conveyor circumferentially enclosing and spaced from the feed conveyor and communicating with the drum through the screen.

4. A ball mill having a rotatable drum for receiving balls and ore aggregate, said drum being mounted for rotation on its horizontal axis, axially longitudinally disposed bays which are substantially the axial width of the drum and extend in circumferentially spaced relation radially outwardly from the outer circumference of the drum, the bays having one longitudinal side opening into the drum, each bay having a forward wall and a follower wall, the follower walls of the bays being transversely crowned centrally of the length thereof and inclined from said crowned central portion towards the relatively opposite ends of the bays, the incline being rearwardly relative to the direction of rotation of the drum, whereby pockets are provided at said opposite ends of the bays, a feed and discharge means mounted at each of the opposite axial ends of the drum and rotatable therewith, and a sifting screen at each opposite end of the drum, the said discharge means at each end of the drum communicating with the drum through the screen.

5. A ball mill having a rotatable drum for receiving balls and ore aggregate, said drum being mounted for rotation on its horizontal axis, axially longitudinally disposed bays which incline rearwardly relative to the direction of rotation of the drum, said bays being relatively spaced circumferentially of the drum and extending radially outwardly from the outer circumference of the drum, each bay having one of its longitudinal sides opening into the drum, the follower walls of the bays being transversely crowned centrally of the length thereof and inclined rearwardly from said crowned central portion relative to direction of rotation of the drum whereby pockets are provided at the opposite ends of the bays, a coaxial feed and discharge means mounted one within the other at each of the opposite ends of the drum and rotatable therewith, and a sifting screen at each of the opposite ends of the

drum, each of the feed means communicating with the drum at the drum axis and the discharge means communicating with the drum through the sifting screen.

6. A ball mill having a rotatable drum for receiving balls and ore aggregate, said drum being mounted for rotation on its horizontal axis, axially longitudinally disposed bays relatively spaced at the outer circumference of the drum, said bays extending radially outwardly from the outer circumference of the drum, each bay having one of its longitudinal sides opening into the drum, said bays being inclined rearwardly relative to the direction of rotation of the drum and having a forward wall and a follower wall, the follower walls of the bays being transversely crowned centrally of the length thereof and inclined rearwardly relative to said direction of rotation from said crowned central portion towards the opposite ends of the bays providing pockets at the opposite ends of the bays into which balls may roll from the crowned central portion, a feed and discharge means mounted at each of the opposite ends of the drum and rotatable therewith, said feed and discharge means at each end of the drum comprising a sifting screen in the end wall of the drum having a central opening therethrough, a tubular helical feed conveyor having one end communicating with the drum through said central opening, and a tubular helical discharge conveyor circumferentially enclosing and spaced from the feed conveyor and communicating with the drum through the screen.



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