April 22, 1958 F. D. DE VANEY 2,831,210

DOCTORING DEVICE FOR BALLING-UP DRUM

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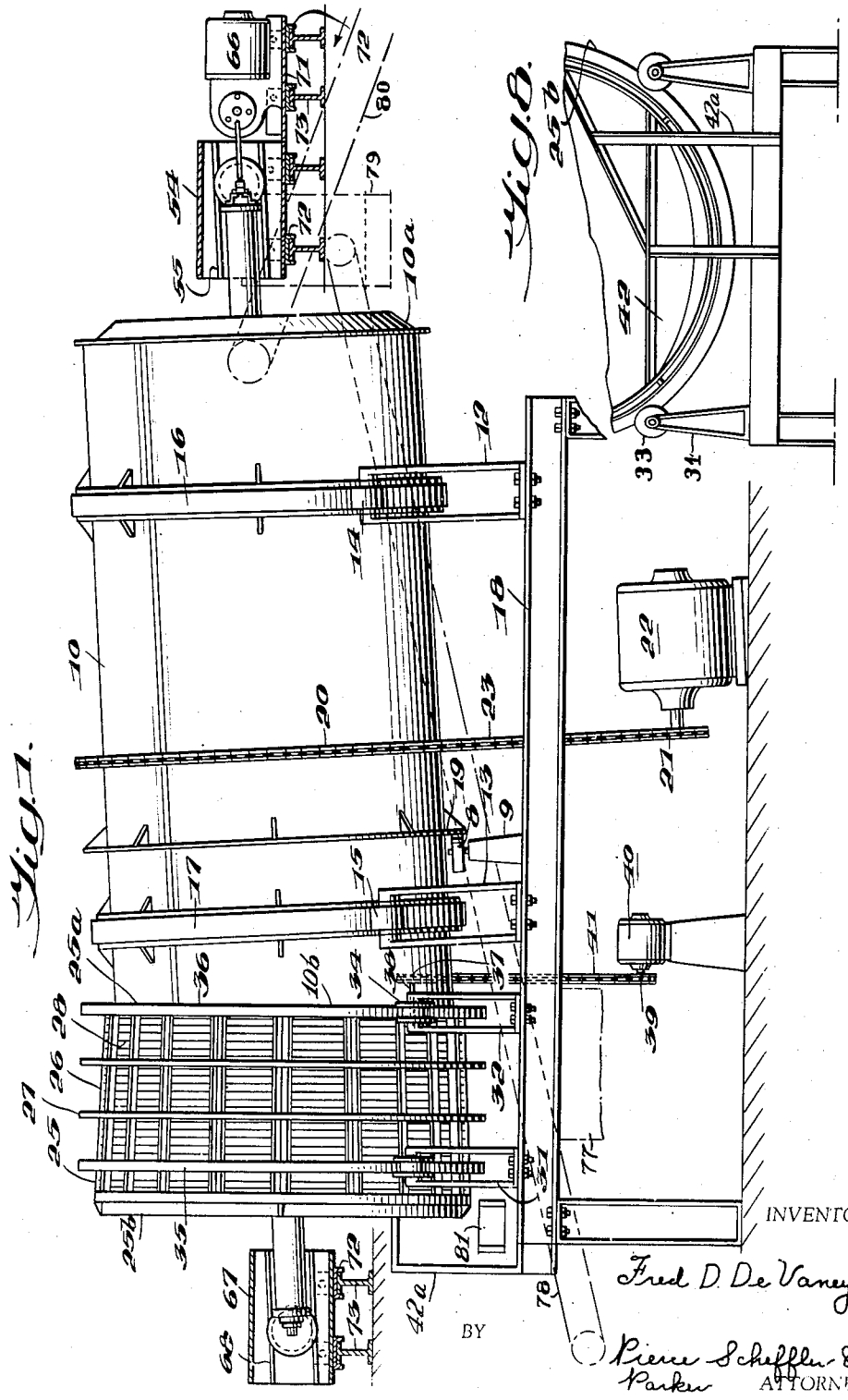


Fig. 1.

Fig. 8.

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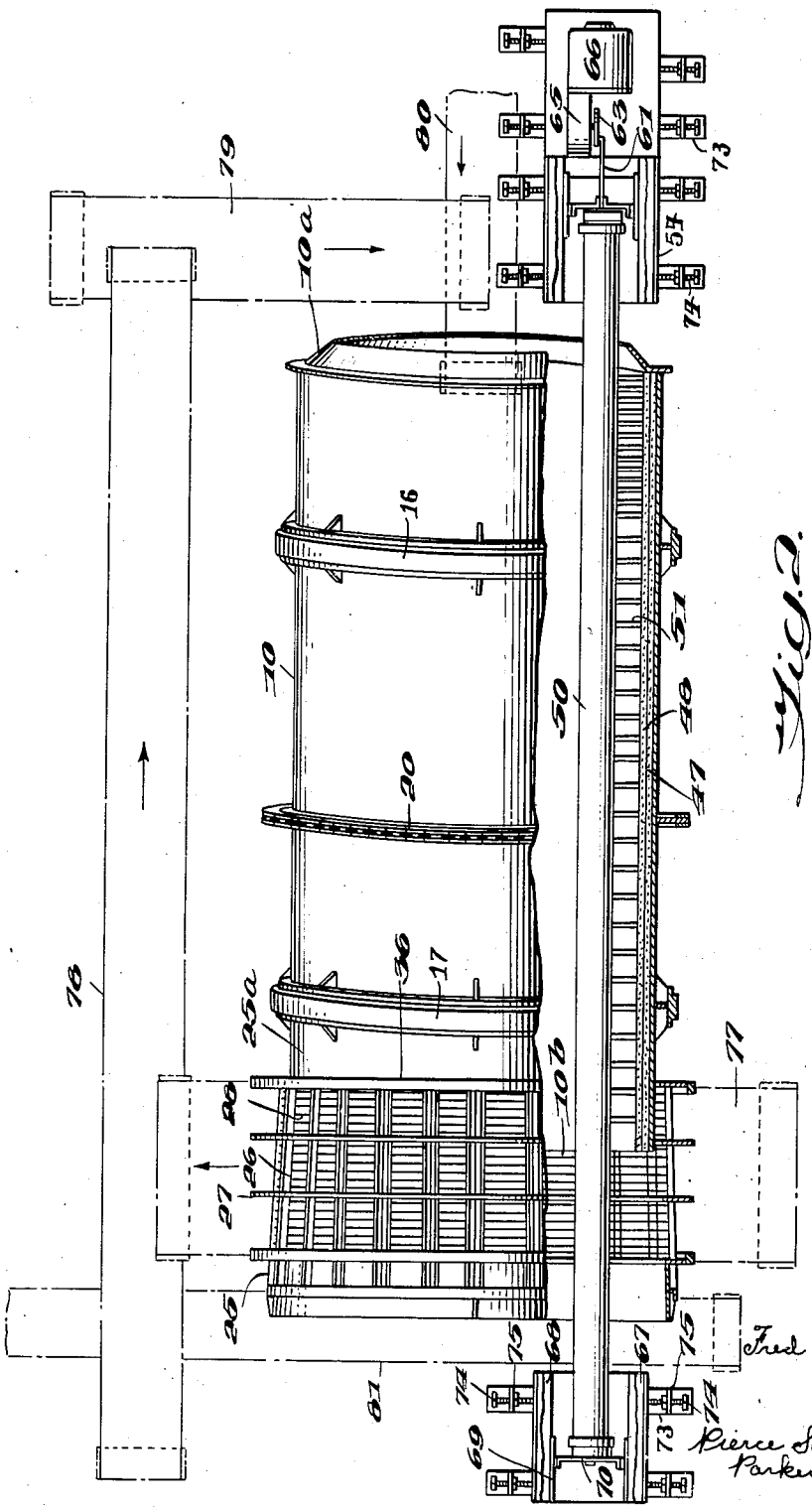


Fig. 2.

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DOCTORING DEVICE FOR BALLING-UP DRUM

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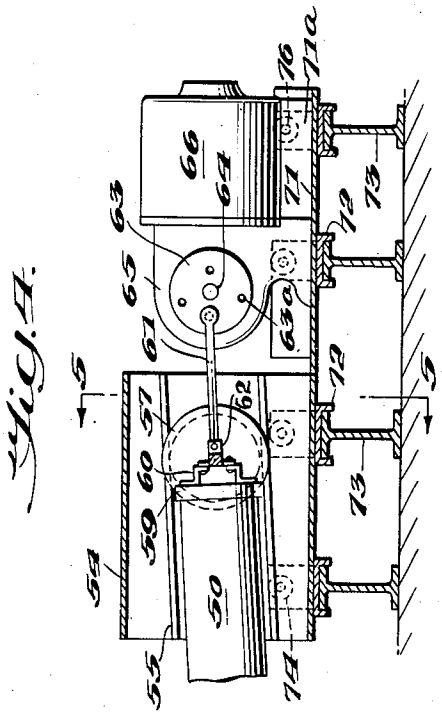


Fig. 4.

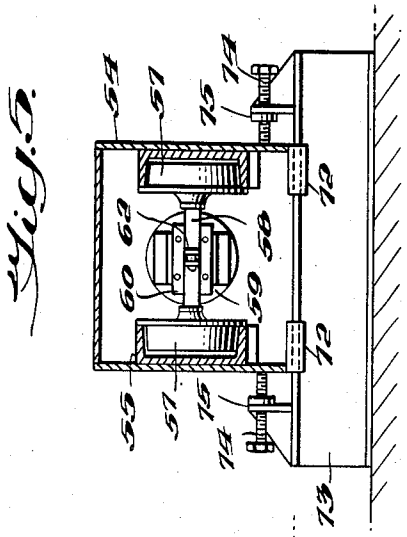


Fig. 2.

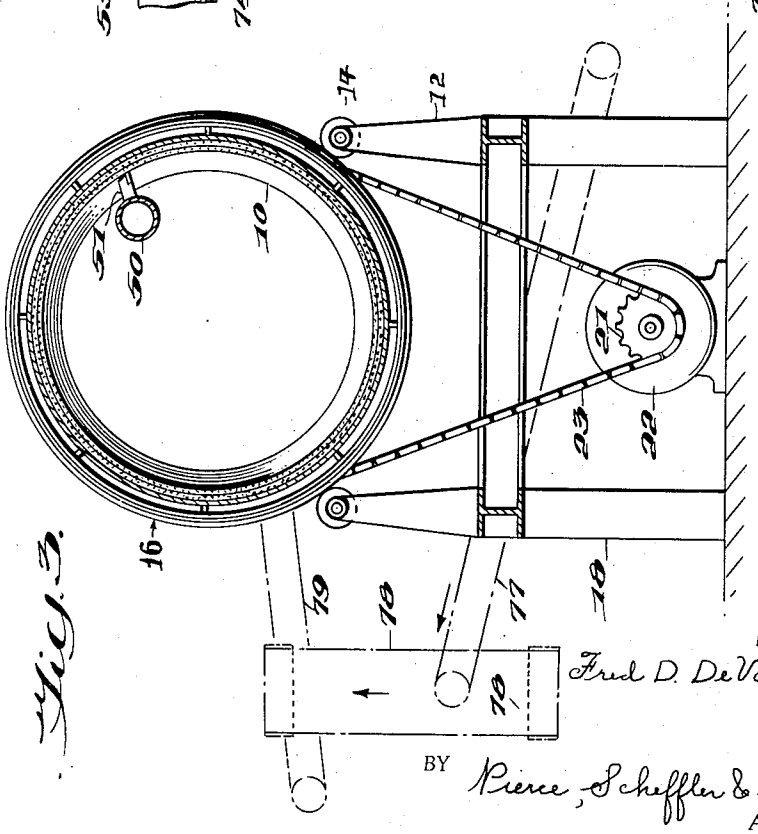


Fig. 3.

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DOCTORING DEVICE FOR BALLING-UP DRUM

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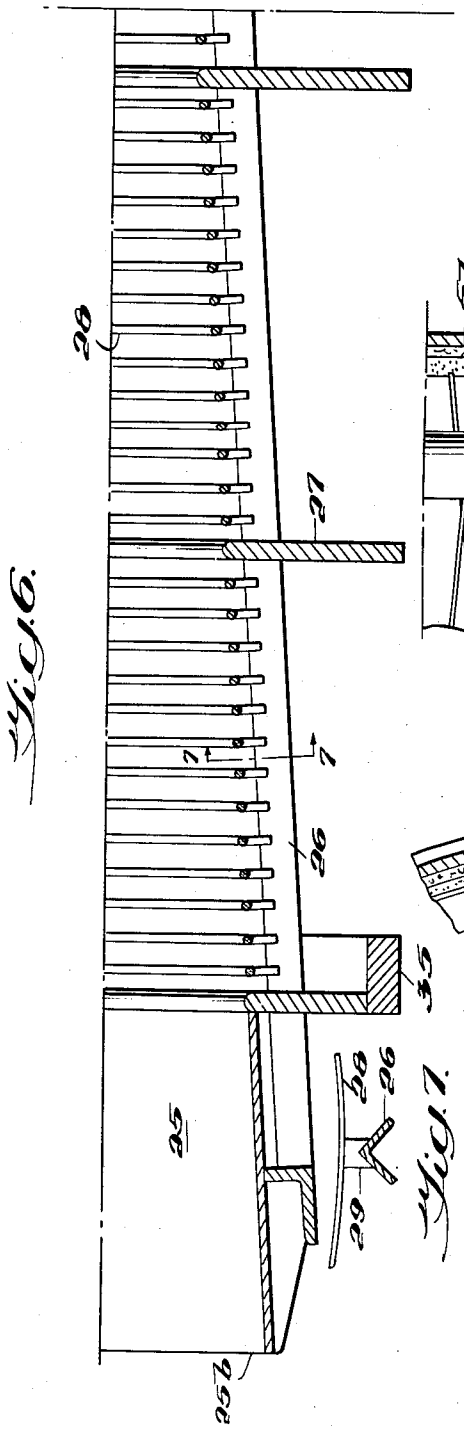


Fig. 6.

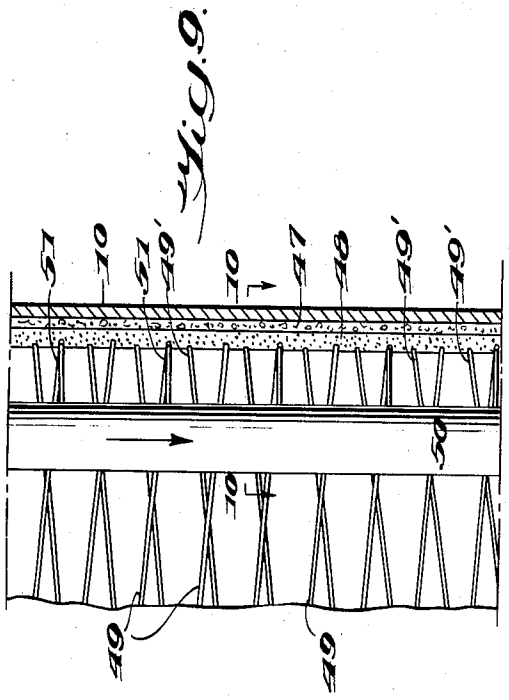


Fig. 9.

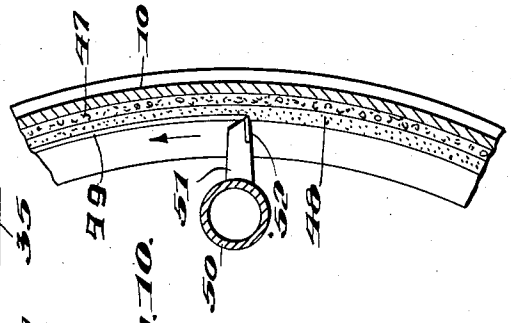


Fig. 10.

Fig. 7.

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United States Patent Office

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Patented Apr. 22, 1958

2,831,210

DOCTORING DEVICE FOR BALLING-UP DRUM

Fred D. De Vaney, Hibbing, Minn., assignor to Erie Mining Company, Hibbing, Minn., a corporation of Minnesota

Application February 16, 1951, Serial No. 211,290

11 Claims. (Cl. 18—1)

This invention relates to the art of agglomerating finely divided mineral material, especially ore concentrates and "fines," and is concerned with improvements in that form of agglomeration wherein initially homogeneously moist finely divided mineral material is pelletized or balled up by passage through a rotating drum and the pellets thereupon are indurated (heat hardened) under conditions to provide mechanically rugged, rock-like bodies.

It has now been found that desirably rugged balls which have a materially reduced tendency to exfoliate can be produced in an industrially feasible manner, by the following improved procedure: The balling-up—or "forming"—operation is carried out in a special form of rotary drum, wherein are observed those conditions (to be more particularly described hereinbelow) as regards character of surface over which the pellets are rolled, mode of insuring proper rolling of the charge, depth of "bed," length of path, peripheral speed of the drum, and other factors which have been found best adapted to the formation of rugged balls of the desired size.

It has been found advantageous to conduct the forming operation in a "closed circuit," i. e., to pass the feed—consisting of fresh moist fines and returned undersized balls or particles from a previous pass—a plurality of times through the forming drum under conditions to promote a relatively slow growth of balls to their desired full size. Thus, it has been found advantageous so to operate the process that in any one "pass" through the drum the feed consists of about one-third fresh moist fines and about two-thirds of "seed" balls from a previous pass. It has been found advantageous, also, to provide a long path of rolling (either by inclining the drum only slightly or by extending the length of the drum, or both), and so to feed that the volume of material being acted on is small with relation to the volume of the drum (whereby to maintain only a relatively shallow pool of the feed material in the drum), and to rotate the drum as rapidly as possible short of that speed at which the feed material tends to be thrown through the air. And, it has been found advantageous if not necessary to form the balls—and to cause "seed" balls to "grow" by slow accretion—by rolling the feed material on a "rolling surface" consisting of a relatively dense, i. e., compacted, layer of the moist fines "lining" the inner periphery of the balling-up drum, the exposed surface of which layer is characterized by a "controlled roughness." This "lining" should be relatively thin as it is not restrained against accidental dislodgment en gross from the drum surface.

Of particular importance to the success of a balling-up process of the type herein contemplated is the maintenance on the inner surface of the drum of a rolling surface of controlled thickness and roughness. Thus, it has been found that when the surface supporting the feed material is smooth, as obtains when the feed material lies adjacent a smooth rubber lining of the drum, or as obtains when a compacted layer of the moist fines is continuously maintained smooth by use of a doctor blade as suggested in Firth Patent No. 2,411,873, the seed balls—and feed material in toto—tend to slide, rather than to roll, on the slick surface thus provided, thereby depreciating the desired result. Moreover, when a broad doctor blade is utilized to work against the cake of moist fines, the cake becomes harder and harder thus making it increasingly difficult to scrape. Also there is a tendency for the drum to chatter and the power consumption is greatly increased.

I have found that the above referred to conditions of controlled thickness and roughness of the surface supporting the feed material can be achieved by continuously doctoring the rolling surface at a plurality of small axially separate areas at a time, said areas being progressively axially shifted so as to effect eventual substantially complete coverage of the rolling surface.

Operable means for effecting the doctoring of the rolling surface as above described are diverse. Thus, the doctoring tools may be teeth which present spaced points to the rolling surface, similar to the teeth of a comb, but preferably they are teeth which present to the rolling surface a plurality of spaced chisel-like edges each a fraction of an inch wide.

It is desirable that the toothed cutter bar be located on the upcoming side of the drum, so that the "cuttings" fall onto the rolling balls and be readily reformed. If the cutter bar were so placed, e. g., on the downcoming side, that the cuttings fell onto the shell, the cuttings would be carried under the balls where they would cause irregularities; moreover, cuttings so rolled on do not readily reform into balls. The teeth are mounted several inches apart along a rigid, non-rotating doctor or cutter bar extending through the rotary drum. The cutter bar is associated with means for reciprocating the same parallel to said rolling surface, whereby progressively to shift the teeth longitudinally so as to induce the doctoring, by each of the latter, of a series of allochiral, i. e. right-hand and left-hand helical "grooves" the adjacent turns of which are spaced apart. Care is taken so to adjust the rate of reciprocation of the cutter bar and the rate of rotation of the rotary drum that the "grooves" cut by any one tooth do not track with each other on successive strokes of the cutter bar, to the end that the teeth edges in the course of a reasonable time interval shall have contacted substantially all of the area of the rolling surface.

A preferred constructional embodiment of the invention is shown in the accompanying drawings in which:

Fig. 1 is a view in side elevation of the balling drum, the improved doctoring apparatus and essential auxiliary components;

Fig. 2 is a top plan view with certain parts broken away to better illustrate the doctoring apparatus;

Fig. 3 is a view in vertical transverse section through the drum;

Fig. 4 is a side elevation with some parts in section of the support for one end of the doctor bar and the reciprocating drive therefor, the view being drawn to an enlarged scale;

Fig. 5 is a vertical transverse section on line 5—5 of Fig. 4;

Fig. 6 is an enlarged fragmentary view illustrating constructional detail of the trommel at the discharge end of the balling drum for screening out undersized balls;

Fig. 7 is a transverse section taken on line 7—7 of Fig. 6;

Fig. 8 is an end view of the trommel at the discharge side thereof;

Fig. 9 is an enlarged, fragmentary detail of the interior of the balling drum; and

Fig. 10 is a transverse section on line 10—10 of Fig. 9.

With reference now to Figs. 1–3 in particular, the balling up apparatus is seen to be comprised of an open ended cylindrical steel drum **10** about 18 feet long and 8 feet in diameter. The drum is supported for rotation in two cradles **12, 13** having smooth rollers **14, 15**, respectively, which engage peripheral steel tires **16, 17** on the drum **10**. Cradles **12, 13** are carried by a framework of steel beams **18** in order to raise the drum sufficiently above the floor line to accommodate the associated conveyor system, driving motors and other related components. Drum **10** is maintained in place on rollers **14, 15** by means of a thrust bearing, constituted by roller **8** journalled on the spindled upper end of upstanding post member **9** supported on frame **18**, which thrust bearing bears against a steel ring **19** encircling and secured to drum **10**. In order to effect movement of the material being balled up axially through the drum **10** as the latter rotates it will be observed that the forward cradle **12** adjacent the loading end **10*a*** of the drum is situated at a level higher than the rear cradle **13** adjacent the discharge end, thus declining the drum in the direction of its discharge end **10*b***. The declination is preferably of the order of ¼ inch to 1 inch per foot of length but has been somewhat exaggerated in the drawing to more clearly indicate its sloping characteristic.

For rotating drum **10** continuously in one direction only there is provided a sprocket and chain type of drive comprising a driven sprocket **20** surrounding the drum, a driving sprocket **21** secured to the shaft of a motor **22** preferably of the type in which its speed can be varied, and a chain **23** extending between the two sprockets. The optimum speed for a drum of the dimensions indicated has been found to be 10.8 R. P. M., which gives a peripheral speed of approximately 275 ft./min. As previously explained, the drum speed is not too critical but is, however, important since the upper speed limit must be somewhat below that at which the balls tend to be thrown from, rather than roll along, the interior surface of the drum.

For screening out undersized balls, a circular trommel **25** is disposed at the discharge end **10*b*** of the balling drum. The trommel is preferbaly of the form shown in the drawings, consisting of generaly frusto-conical skeleton framework made up from an array of lengths of angle stock **26** held in spaced relation by a plurality of axially spaced bands **27** and a helix of round bar stock **28** secured to plates **29** upstanding upon the angles **26** as best shown in Figs. 6 and 7. The diameter of the bar stock **28** and the spacing between adjacent turns thereof will be dictated by the size of ball desired to be returned for another pass through the balling drum **10** for further "growth." In the embodiment of the invention as actually constructed, however, the bar stock used for forming the helical screen was 5/16" in diameter and the distance between centers of adjacent turns of the helix was 15/16", giving a clear opening of 5/8".

The wires or rods which make up the screening surface of the trommel may be either concentric or—as shown—spirally disposed in a direction which will tend to facilitate discharging the finished balls.

The internal diameter of trommel **25** at its inlet end **25*a*** is slightly larger than the external diameter of drum **10** so as to permit the former to telescope over the latter, and its discharge end **25*b*** has an internal diameter larger than that at the inlet end **25*a*** thus establishing a tapered surface dipping in the direction of the feed of the balls through drum **10**. The trommel is disposed with its major axis horizontal. In the actual construction, the internal trommel diameters at the inlet and outlet ends were approximately 8.5 feet and 9.2 feet, respectively. The declination of the inside surface of trommel **25** was approximately 1⅞ inches per foot of length. The length of the trommel was about 4.5 feet.

As in the case of drum **10**, the trommel **25** is supported on two cradles **31, 32** provided with sets of grooved rollers **33, 34**, respectively, which engage steel tires **35, 36**. Trommel **25** also rotates and its driving mechanism is also of the chain-sprocket type including a driven sprocket pinion **37** keyed to shaft **38** (see Fig. 1) to which shaft roller **34** is also keyed, a driving sprocket **39** on the drive shaft of motor **40** and a chain **41**. Preferably trommel **25** rotates at approximately 7 R. P. M., i. e., slightly slower than drum **10**.

It is to be noted that in a case where the diameters of the drum and trommel differ from the specific values above mentioned the drum and trommel are to be operated at speeds which will give approximately the same relation of peripheral speeds, in feet per minute.

At the discharge end **25*b*** of the trommel as seen in Fig. 8, a transverse barrier **42**, supported by suitable bracket means **42*a***, is erected to deflect balls, which may have been caught in the trommel opening, and carried to near the top of the trommel, in such manner that such balls may drop onto the screening surface rather than fall into the discharge. As shown in Fig. 1, balls discharge from trommel **25** onto conveyor belt **81**, to be carried by the latter to a point of use or further treatment. Advantageously, conveyor belt **81** is disposed with its long axis normal to the horizontal axis of trommel **25**.

Reverting to the drum **10**, and with particular reference to Figs. 2, 9 and 10, it will be seen that the interior surface of the steel drum **10** is lined with a layer of concrete **47** preferably from 1 to 3 inches thick or other material having a moderately rough surface such as an expanded metal lathe, upon which is allowed to build a second dense layer **48** of the moist ore fines. Layer **48** is maintained at a thickness of approximately 1 inch by the doctoring device and is the layer upon which the seed balls are caused to roll and grow slowly in diameter by the process of accretion.

As explained in the introduction, it is most important that the seed balls be made to roll rather than slide upon the interior surface of the drum **10**. To this end, the present invention provides for maintaining an optimum degree of roughness on the surface of layer **48** and specifically by means which continuously doctor the surface at a plurality of small and axially separate areas at a time, the doctored areas being progressively axially shifted so as to effect eventual substantially complete coverage of the rolling surface.

Apparatuswise, doctoring of the surface layer **48** is done by means of a doctor or cutter bar extending longitudinally through the drum **10** and trommel **25** as shown at **50**. Bar **50** is positioned at the "2 o'clock" position, so that cuttings produced by its teeth, during counter-clockwise rotation of the drum, as viewed in Fig. 3, may fall upon the rolling balls. Bar **50** is preferably made from 10" diameter, extra heavy pipe in order to insure axial rigidity and has secured to it a plurality of teeth **51** projecting laterally therefrom and positioned to engage and cut the surface of layer **48**. The cutting edge of each tooth is preferably constituted by a renewable insert **52** made from a metal carbide such as that sold under the tradename "Carset," and presents a cutting edge about 0.25" in width. At the inlet end to drum **10**, the teeth **51** are spaced comparatively close together, i. e., about 4" apart for an axial distance of about four feet in order to cope with the heavy "build-up" of feed material which tends to deposit at a greater rate at this end of the drum. The spacing between the teeth **51** for the remainder of the axial length of the drum is approximately 8".

Provision is made to reciprocate the cutter bar **50** at a rate of four strokes per minute and the length of the stroke of reciprocation is about 8.25" (i. e., just enough to insure the meeting of areas influenced by adjacent ones of the 8" spaced teeth). The reciprocating motion of the cutter bar **50** coupled with rotary motion of

drum 10 results in a doctor pattern consisting of a series of 0.25" wide criss-cross allochiral spiral grooves. The grooves of one hand cut by successive passes of the cutter teeth in one direction are designated by numeral 49 and those of the opposite hand produced by successive passes of the cutter teeth in the opposite direction are designated by numeral 49'. With the dimensions and rate of motion given, the grooves cut in the layer 48 by any one of the teeth 51 during successive strokes of the cutter bar will not track or register with each other thus assuring working of the entire surface area of the compacted layer 48 of moist fines in due course. While the base of each groove so cut presents a smooth surface that would tend to cause a sliding movement of the balls the groove is narrow enough to prevent the smallest of the seed balls from getting down into it. Thus the surface of layer 48 is maintained in a constant state of roughness and never presents any smooth portions which could cause the balls to slide.

Each of the criss-crossed right and left hand grooves 49, 49' and particularly those near the loading end of drum 10 actually begin to refill with the moist fines present in the drum not long after they have been cut by the teeth 51. Consequently the grooved doctor pattern would actually not acquire a degree of distinctiveness as sharp as that pictured in Fig. 9 which has purposely been exaggerated in order to more clearly illustrate this important aspect of the present invention.

The roughened surface of layer 48 causes the balls to be carried up the wall of the drum 10 as the latter rotates until the holding friction is overcome whereupon the balls then roll down the drum wall and accumulate more of the loose moist fines.

The cutter bar 50 is supported at each end thereof by a wheeled axle that rolls on an associated trackway. The enlarged views of Figs. 4 and 5 show the details of construction employed at the end connected to the motor which furnishes the power for reciprocating the cutter bar. Here the details are seen to include an open-ended rectangular housing 54 the side walls of which are provided with confronting [-shaped channels 55 which serve as a trackway for the wheels 57 journalled on axle 58. A cap 59 is fitted upon the end of bar 50 and brackets 60 connect the cap 59 and hence the cutter bar to axle 58.

A crank arm 61 having one end thereof pivotally secured by a clevis 62 to axle 58 extends to an eccentric plate 63 which is secured upon the output shaft 64 from a speed reduction unit 65 powered by motor 66. Plate 63 is preferably provided with a plurality of eccentric pins 63*a* located at different radii from the center, to any one of which crank arm 61 is connected thereby enabling one to adjust the stroke of the cutter bar 50.

The support for the opposite end of the cutter bar is similar including an open-ended rectangular housing 67 having [-shaped channels 68 forming a trackway for wheels 69 journalled upon axle 70 to which the capped end of the cutter bar is secured. As shown in Fig. 1 the trackway channels 55, 68 preferably are inclined at the same angle as the balling drum 10.

To the underside of the trackway housings 54, 67 and also the support plate 71 for motor 66 are secured channel members 72 which seat upon eye beams 73. Cutter bar 50 is preferably so disposed that the teeth 51 cut to within about one inch from the inner surface of the concrete liner 47—i. e., the compacted layer 48 of moist fines left undisturbed by the action of the teeth is about one inch thick.

To compensate for tooth wear and other variable factors, provision is made for adjusting the cutter bar 50 transversely of its axis. To this end and with reference to Fig. 5 in particular it will be seen that the channels 72 and hence housings 54, 67 are slidable longitudinally along beams 73 and are fixed in any selected position of adjustment by means of spaced pairs of adjusting screws 74 the ends of which bear against the outer surface of the housings 54, 67. The screws 74 thread through brackets 75 secured upon beams 73 and hence the housing adjustment may be effected by turning down the screws 74 at one side of the housings and backing off by a corresponding amount the screws at the other side of the housings. Motor 66 must also be adjustable transversely to maintain alignment in the connections between the motor and cutter bar, and hence it will be seen that similar adjusting screws 76 are provided for engagement with the upturned sides 71*a* of the motor support plate 71.

It will be remembered from the introduction that the balling up process contemplates passage of the initially small seed balls on an average of three times through the balling drum 10 in order to promote a slow growth of the balls to the desired minimum diameter. The same effect is not secured by tripling the length of the balling drum; for the desired growth, partially grown balls should be returned to the drum and come in contact with fresh new feed.

A conveyor system is employed, and is best shown in Figs. 1, 2 and 3. An inclined endless belt type of conveyor 77 located beneath and extending transversely of the trommel 25 receives all undersized balls and fines that drop through the interstices in the helical screen 28. Conveyor 77 carries the balls and fines laterally outward from the trommel and discharges onto another inclined endless belt conveyor 78 extending parallel with the drum 10, and which is used to transport the material rearwardly to the loading end of the drum. Here the material is transferred to another belt conveyor 79 for transport laterally inward and final discharge upon conveyor 80 on which the fresh fines and seed balls are brought to the loading end of drum 10 which is coned as shown to prevent spillage. After the balled up ore fines have grown to a diameter where they no longer are able to pass through the trommel screen, they will discharge onto conveyor 81 for transport to the indurating furnace.

In conclusion, it will now be evident that the improved method and apparatus for doctoring the surface of the compacted layer of ore fines serves not only to keep the layer from building up to such thickness and weight where large portions would tend to break off but also maintains the surface of the layer in a state of roughness which enhances the desired rolling action of the balls along the interior of the drum and reduces any tendency on the part of the balls to slide rather than roll.

Moreover, it is to be understood that while the embodiment of my invention as illustrated is to be preferred, various minor changes may be made in the construction and arrangement of the component parts without, however, departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. Apparatus for forming moist finely divided loose mineral matter such as ore fines into balls comprising an inclined elongated hollow drum having, during use, at least the greater part of its inner surface lined with a compacted layer of the ore fines constituting a rolling surface for the loose fines, means for feeding loose fines into the higher end of said drum, means for rotating said drum on its longitudinal axis, doctoring means for continuously limiting the thickness of such compacted layer, said doctoring means being stationary with respect to the rotation of said drum and adapted to contact, and continuously limit the thickness of, said compacted layer along a plurality of spaced apart, relatively narrow, parallel paths extending circumferentially of the exposed surface of said compacted layer, said doctoring means including means for shifting the paths progressively in a direction longitudinally of said drum so as to effect eventual doctoring of the entire area of said compacted layer.

2. Apparatus for forming moist finely divided loose mineral matter such as ore fines into balls comprising, an inclined elongated hollow drum having, during use, its inner surface lined with a compacted layer of the ore fines constituting a rolling surface for the loose fines, means for loading loose fines into the higher end of said drum, means for rotating said drum about its longitudinal axis, a plurality of rotationally stationary relatively closely spaced and narrow teeth disposed longitudinally of said drum in engagement with said compacted layer to make a series of generally parallel cuts in the latter, and means for progressively shifting said teeth longitudinally of said drum simultaneously with rotation of the latter thereby to cause each of said teeth to make a spiral cut in the surface of said compacted layer.

3. Apparatus for forming moist finely divided loose mineral matter such as ore fines into balls comprising, an inclined elongated hollow drum having, during use, its inner surface lined with a compacted layer of the ore fines constituting a rolling surface for the loose fines, means for loading loose fines into the higher end of said drum, means for rotating said drum about its longitudinal axis, a plurality of rotationally stationary relatively closely spaced and narrow teeth disposed longitudinally of said drum in engagement with said compacted layer to make a series of generally parallel cuts in the latter, and means for reciprocating said teeth longitudinally of said drum simultaneously with rotation of the latter thereby to cause each of said teeth to make a series of non-registering allochiral spiral cuts in the surface of said compacted layer.

4. Apparatus for balling-up mineral matter as defined in claim 3 wherein the stroke of reciprocation of each tooth is substantially equal in length to the spacing between the widest spaced teeth.

5. Apparatus for balling-up mineral matter as defined in claim 3 wherein the teeth at the loading end of said drum are more closely spaced than the remainder thereof.

6. Apparatus for forming moist finely divided loose mineral matter such as ore fines into balls comprising, an inclined elongated hollow drum having, during use, its inner surface lined with a compacted layer of the ore fines constituting a rolling surface for the loose fines, means for feeding loose fines into the higher end of said drum, means for rotating said drum about its longitudinal axis, a rigid cutter bar extending longitudinally within said drum, a plurality of rotationally stationary relatively closely spaced and narrow teeth arranged longitudinally of said bar and secured thereto, said teeth being positioned to engage said compacted layer to make a series of generally parallel cuts in the latter, and means for reciprocating said cutter bar longitudinally of its axis simultaneously with rotation of said drum thereby to cause each of said teeth to cut a series of non-registering allochiral spiral grooves in the surface of said compacted layer.

7. Apparatus for balling-up mineral matter as defined in claim 6 wherein the stroke of reciprocation of said cutter bar is substantially equal in length to the spacing between the widest spaced teeth.

8. Apparatus for balling-up mineral matter as defined in claim 6 and which further includes means for adjusting

said cutter bar in a direction normal to its longitudinal axis thereby to effect an adjustment in the depth of cut of said teeth.

9. Apparatus for forming moist finely divided loose mineral matter such as ore fines into balls comprising, an inclined elongated hollow drum having, during use, its inner surface lined with a compacted layer of the ore fines constituting a rolling surface for the loose fines, means for feeding loose fines into the higher end of said drum, means for rotating said drum about its longitudinal axis, a rigid cutter bar extending through said drum, a wheeled axle supporting said bar at each end thereof, a trackway for each of said wheeled axles extending longitudinally of said bar, a plurality of relatively closely spaced and narrow teeth arranged longitudinally of said bar and secured thereto, said teeth being positioned to engage the surface of said compacted layer, and means for reciprocating said wheeled axles and hence said bar longitudinally of its axis simultaneously with rotation of said drum to cause each of said teeth to cut a series of non-registering allochiral spiral grooves in the surface of said compacted layer.

10. Apparatus for balling-up mineral matter as defined in claim 9 and which further includes means for adjusting said trackways and hence said bar in a direction transverse to the longitudinal axis of the latter thereby to effect an adjustment in the depth of cut of said teeth.

11. Apparatus for forming moist finely divided loose mineral matter such as ore fines into balls said apparatus comprising an inclined elongated hollow drum having, during use, at least the greater part of its inner surface lined with a compacted layer of the moist ore fines constituting a rolling surface for the loose fines, means for feeding loose moist fines into the higher end of the drum, means for rotating said drum on its longitudinal axis, means operatively associated with the lower end of said drum for screening loose moist fines and undersized balls from the product continuously discharged from the lower end of said drum, means for returning the screenings to the higher end of said drum, and doctoring means for continuously limiting the thickness of such compacted layer, said doctoring means being stationary with respect to the rotation of said drum and adapted to contact, and continuously limit the thickness of, said compacted layer along a plurality of spaced apart, relatively narrow, parallel paths extending circumferentially of the exposed surface of said compacted layer, said doctoring means including means for progressively shifting the paths in the direction of the longitudinal axis of the drum whereby to effect eventual doctoring of the entire area of said compacted layer.

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