April 18, 1961 O. H. JOHNSON 2,980,352

GRINDING MILLS

Filed Dec. 22, 1958 3 Sheets-Sheet 1

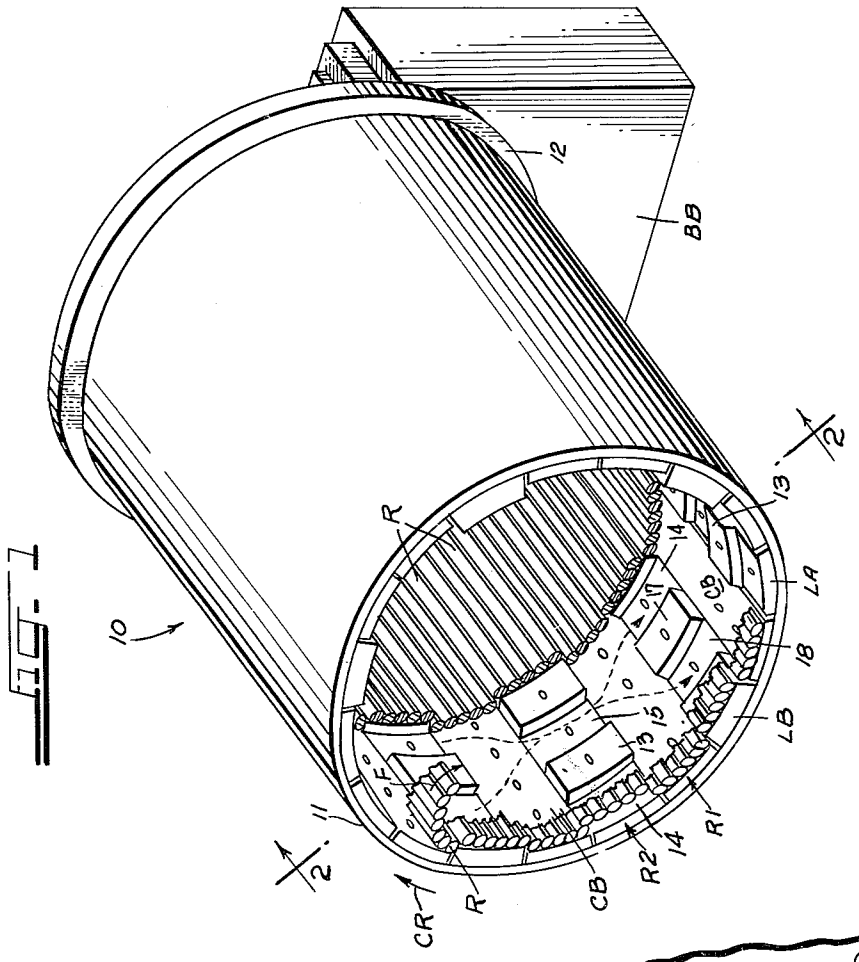


FIG. 1

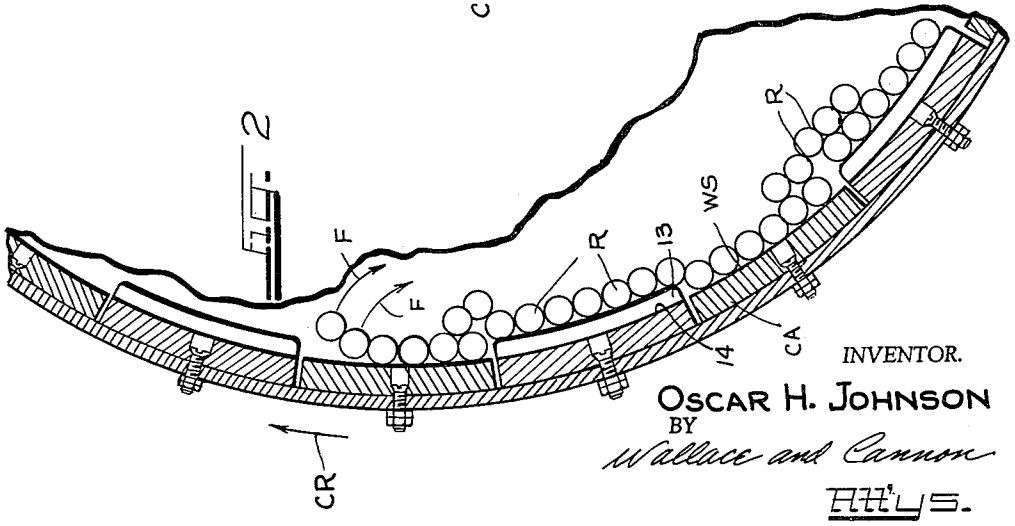


FIG. 2

INVENTOR.

OSCAR H. JOHNSON

BY

Wallace and Cannon

Attys.

April 18, 1961 O. H. JOHNSON 2,980,352

GRINDING MILLS

Filed Dec. 22, 1958 3 Sheets-Sheet 2

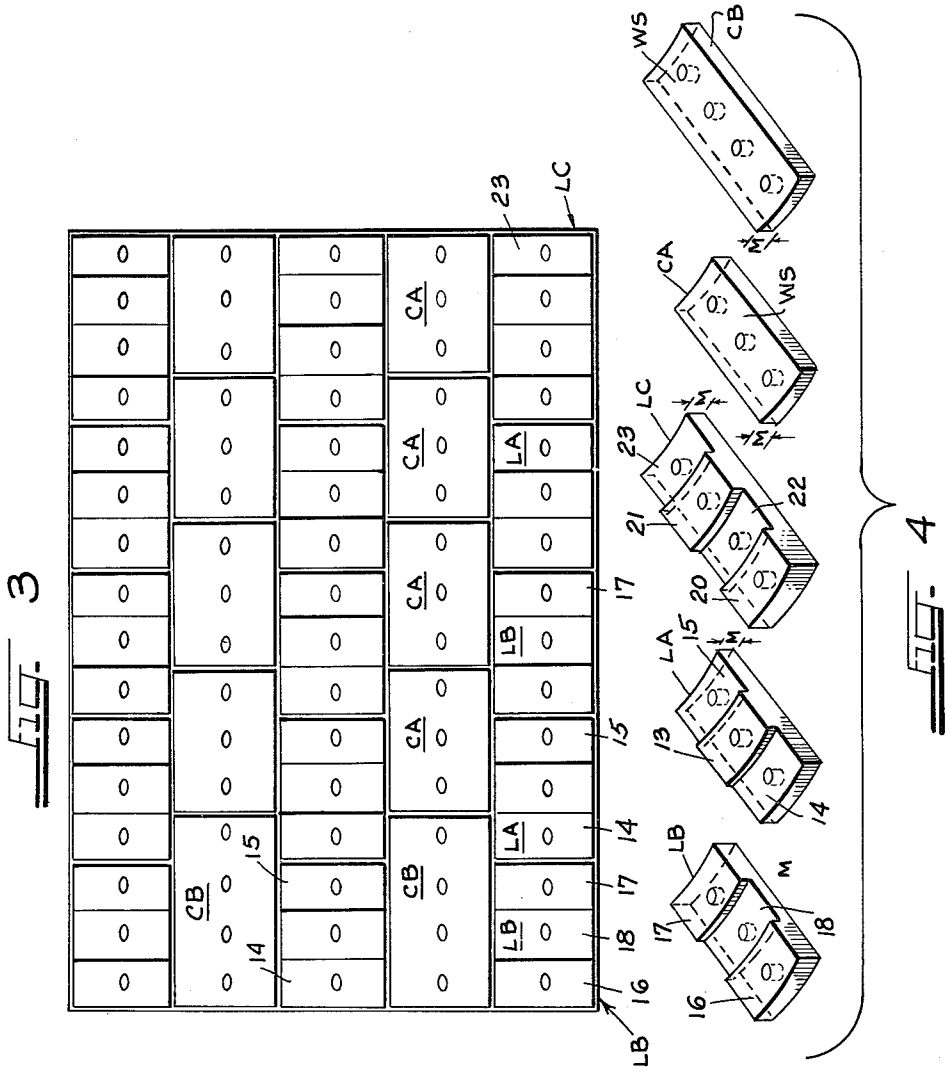


FIG. 3

FIG. 4

INVENTOR.

OSCAR H. JOHNSON

BY

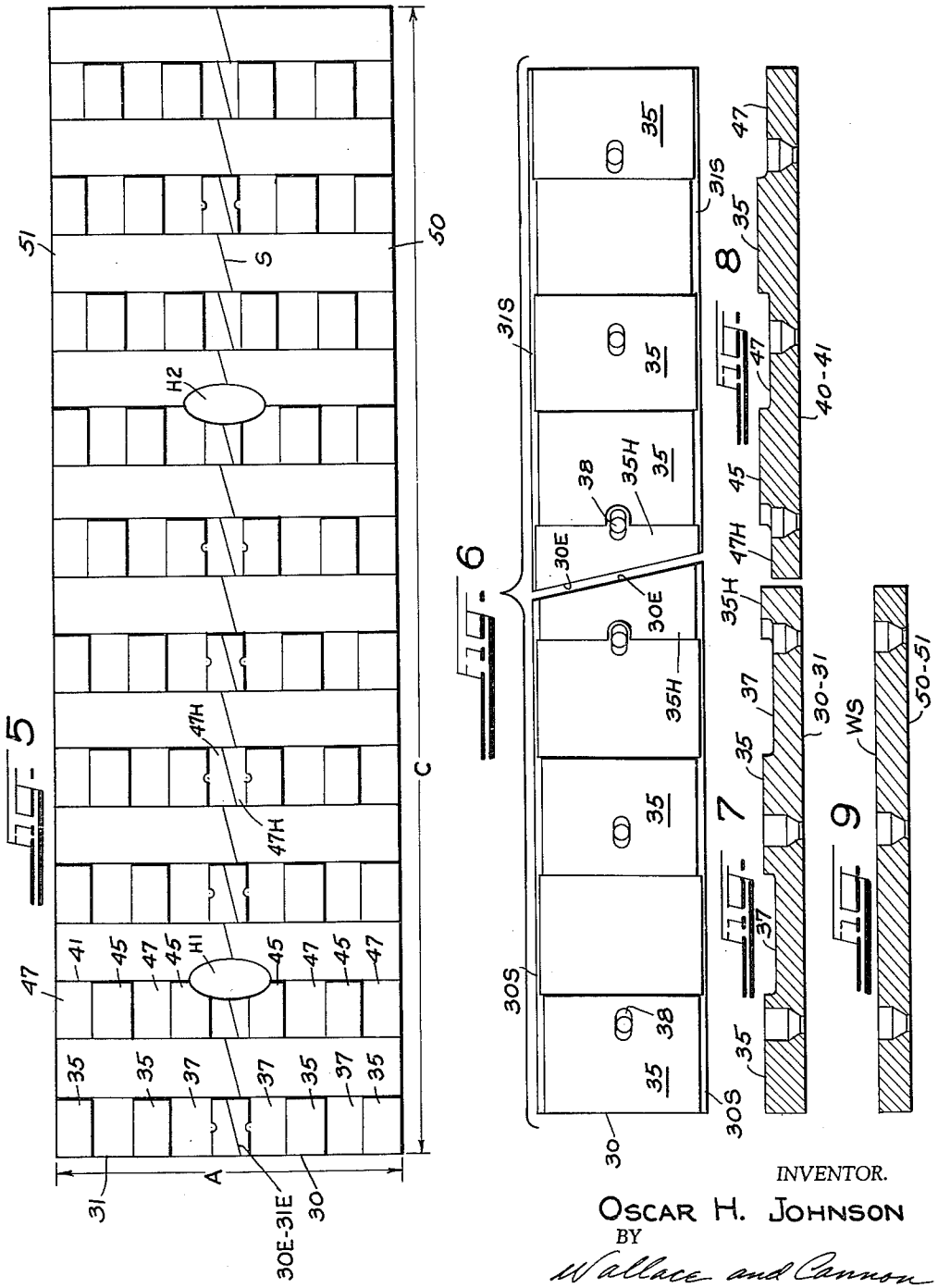
Wallace and Cannon

Attys.

April 18, 1961 O. H. JOHNSON 2,980,352

GRINDING MILLS

Filed Dec. 22, 1958 3 Sheets-Sheet 3



INVENTOR.

OSCAR H. JOHNSON

BY

Wallace and Cannon

ATTYS.

United States Patent Office 2,980,352 Patented Apr. 18, 1961

2,980,352

GRINDING MILLS

Oscar H. Johnson, Denver, Colo., assignor to American Brake Shoe Company, New York, N.Y., a corporation of Delaware

Filed Dec. 22, 1958, Ser. No. 782,222

5 Claims. (Cl. 241—183)

This invention relates to grinding mills which use rods or balls or selected pieces of ore as the grinding media, and is concerned in particular with the construction of the liner for the shell of the mill.

It is conventional practice in the grinding mill art to line both the shell and the end walls with replaceable linears of wear-resistant material such as maganese steel or like ferrous metal alloy which is resistant to attrition and impact types of wear. These liners are what take the wear, thereby protecting the more expensive shell and end walls, and when the liners become unduly worn the mill is temporarily shut down and relined where necessary.

Over the years, different shapes and configurations have been imparted to the liners for imparting certain types of action to the grinding media in order to either enhance the efficiency of the mill or prolong further the life of the liner elements. For instance, it is conventional to so form the liners for the shell as to account for a wave or rib-like appearance of the shell liner, but I have found that such rib-like shell liner constructions account for a great deal of slippage of the grinding media whether these be rods, balls or selected pieces of ore. In this connection, it should be mentioned that the most efficient types of comminution within a grinding mill is that which follows from an actual forceful impact of the grinding media on the charge. The next most efficient type of comminution is that caused by a rolling action of the grinding media on the charge. Virtually no comminution occurs as a result of the grinding media simply sliding or slipping one over the other within the mill, and I have found that the wave-type or rib-type shell liners encourage a great deal of slippage within the mill thereby lowering the grinding efficiency. Accordingly, the primary object of the present invention is to so construct a shell liner for a grinding mill as to account for high efficiency in impact and attrition grinding. Specifically, I achieve this by constructing the shell liner of alternate rows of dissimilar liners herein designated as conveyor liner rows and lifter liner rows. The conveyor liner rows comprise liner plates of relatively shallow thickness dimension, and the lifter liner rows comprise plates having spaced apart raised pads or projections that are of substantially greater thickness than the conveyor plates. The spaces between the raised parts of the lifters are occupied by depressed portions which have substantially the thickness dimension of the conveyor plates. This particular construction enables the grinding media to be virtually locked to the shell as will be explained so as to be carried around with the shell with virtually no inefficient backsliding, and when the force of gravity on the grinding media overcomes the centrifugal force of the mill the grinding media take flight and fall with a violent force downward in a deflected direction toward the opposite side of the mill with the consequent result of a great deal of impact grinding on the charge within the mill.

The foregoing explains the primary principle of the present invention, and this principle together with ancillary features will be more apparent from and will be explained in greater detail in connection with the description of the present construction of grinding mill shell liners.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration show a preferred embodiment of the present invention and the principle thereof and what is now considered to be the best mode contemplated for applying this principle. Other embodiments of the invention embodying the same or equivalent principle may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

In the drawings:

Fig. 1 is a perspective view of a grinding mill having a shell liner constructed in accordance with the present invention, one end of the mill being open to reveal the internal construction;

Fig. 2 is a sectional view on an enlarged scale of a portion of the shell of the mill in Fig. 1 lined in accordance with one plan under the present invention;

Fig. 3 is a plan view showing the precise manner in which liner plates are arranged under one plan;

Fig. 4 is a perspective view showing the various kinds of liner plates designated in Fig. 3;

Fig. 5 is a plan view of another installation constructed in accordance with the present invention;

Fig. 6 is a plan view on an enlarged scale of two of the lifter plates shown in Fig. 5;

Fig. 7 is a sectional view through either of the plates 30 and 31 in Fig. 6;

Fig. 8 is a sectional view through either of the plates 40 and 41 in Fig. 5;

Fig. 9 is a sectional view of a conveyor plate for the installation shown in Fig. 5.

Grinding mills in actual practice are constructed in many different forms for different purposes depending primarily upon the type of material to be comminuted and the manner in which the charge is to be fed to and withdrawn from the mill. The mill 10 in Fig. 1 of the drawings is illustrated schematically for the most part, since the present invention is concerned with the construction of a shell liner rather than the operation details of the mill as a whole. The mill 10 includes a cylindrical shell or drum 11 which affords the chamber in which the charge and the grinding media are confined for action. The ends of such a mill are closed off by end walls as 12 securely locked to the shell, and these end walls are provided with trunnions (not shown) that are supported in bearings which in turn are part of the standards or bearing blocks as BB which support the mill for rotation. One of the end walls is usually provided with an inlet of one kind or another for the charge that is to be comminuted, and the other end wall is usually provided with a take-off for the resultant fines. Movement of the charge through the mill can be one of gravity as a result of tipping the mill slightly or can be one induced by hydraulic flow or can be one characterized by flow through a gridded cover end behind which are pumping vanes for increasing the flow by reducing the pulp level within the mill. Additionally, one of the end walls usually includes a driven gear that rotates the mill.

As shown in Figs. 1 and 2, the mill 10 is illustrated as employing rods R as the grinding media, but the principles of the present invention are applicable to mills which use other type grinding media such as balls and ore, and hence various forms of grinding media capable of rolling on one another are contemplated. It will be

appreciated that the shell of the mill will be subjected to a tremendous beating during actual operation, and since the shell of the mill is quite expensive it is conventional practice to protect the shell against damage by lining the same with expandable liners as mentioned above. In accordance with the present invention, the shell is lined so as to have alternating rows of dissimilar liners which are so constructed as to greatly improve the action of the grinding media, and this construction will now be explained in detail.

Referring to Fig. 1, the reference characters R1 and R2 are used to identify respectively the conveyor liner rows and the lifter liner rows, and these rows of liners alternate circumferentially about the mill. It will moreover be noted that each lifter liner row has spaced projections of quite generous area, whereas the conveyor liner row has no such projections. This particular construction enables several of the grinding media to rest on the elevated surfaces of the projecting members comprising the lifter liner, and these media, as will be observed in Figs. 1 and 2, occupy elevated positions in comparison to the grinding media which engage the conveyor liners. Additionally, the rows of lifter liners are off-set longitudinally of the mill, and this produces an advantageous tortuous flow of fines within the mill as will be explained.

Each shell liner row in the mill is made up of individual plates secured to the shell in a conventional style, and referring to Fig. 3 the conveyor liner plates include a plurality of short plates CA which are of rectangular dimension and which are laid end to end in a row along the length of the mill parallel to the longitudinal axis. Because of the off-setting of the lifter rows to be described hereinafter, an oversized conveyor liner plate CB is provided for finishing off one end of the conveyor plate row as shown in Figs. 1 and 3. The plate CA will of course have a predetermined length and width dimension suited to the particular installation involved, and the end plates CB will be approximately one-third longer. For instance, in a mill of approximately sixteen feet axial length and having twenty rows of liners in accordance with the present invention, the plates CA are two feet eleven and one-half inches in length with a width of nineteen and three-fourths inches. The plates CB have the same width but have a length of three feet eleven and one-half inches. The plates CA and CB have a thickness dimension of three inches under these circumstances, but this dimension can be changed depending upon the severity of grinding to be expected.

The lifter liner rows also comprise individual plates that are secured in a conventional style to the shell of the mill, and these lifter rows alternate with the conveyor rows as was mentioned above. In constructing and assembling the lifter liner rows, a plurality of short plates LB are used, and these plates have the length and the width of the conveyor plates CA. However, each lifter plate LA at a point intermediate the ends thereof is formed with a projecting pad or block **13** which projects above the plane of the depressed surfaces or ledges **14** and **15** on either side thereof a distance equal to at least one-third the diameter of the grinding rod or ball used in the mill. Stated in other words, the wear surfaces **14** and **15** on the plates LA lie in the plane of the wear surfaces WS of the conveyor plates CA and CB as will be apparent from Fig. 2, such that the plates LA have a thickness dimension equal to that of the plates CA and CB measured between the wear surface **14** or **15** and the opposing surface which engages the inner wall of the shell. This dimension is indicated at M in Fig. 4 and is utilized in all the liner plates shown in Figs. 3 and 4.

It will be recognized from the foregoing that the lifter plates LA have two ledges **14** and **15** on opposite sides of the elevated pad **13** which are equal in length and width to the pad **13**. As shown in Fig. 3, these plates LA are used at alternate locations along the length of row of lifter plates. Also included in the lifter liner rows are lifter plates LB and LC of somewhat different configuration or dimension as will now be explained. The lifter plates LB, like the plates LA, are of the same length and width dimension as the conveyor plates CA. However, the plates LB have two spaced projecting pads or blocks **16** and **17** at the two ends thereof, and these parts **16** and **17** are separated by a shallow or depressed portion **18** which in the assembly will be coplanar with the wear surfaces of the ledges **14** and **15** on the plates LA. The pads **16** and **17**, and the depressed surface **18** therebetween, are equal in area dimension and are equal in area dimension to the parts **13**, **14** and **15** of the plates LA.

The lifter plates LC have the length and width dimensions of the conveyor plates CB. The lifter plates LC have projecting blocks or pads arranged in spaced relation thereon, identified at **20** and **21**. These blocks project above the adjacent ledge surfaces **22** and **23** to the same height as the blocks **13**, **16** and **17** described above, and it will be recalled that this projecting or excess distance in each instance is at least equal to one-third the diameter of the grinding media used in the mill. In reality, the lifter plates LC are of one-third greater length than the plates LA and LB.

The pattern of assembly is illustrated in plan in Fig. 3. Thus, all the rows of conveyor liners are arranged in an identical pattern with the long plates CB at the left hand end of the assembled shell liner as viewed in Fig. 3. The alternate rows of lifter liners are, however, in effect off-set with respect to one another. Thus, considering the five rows of liners illustrated in Fig. 3 as being numbered from top to bottom, it will be noted that the first row is a lifter row, and the left hand end plate of this row is occupied by a lifter plate LB having two upstanding blocks **16** and **17**. Continuing down the row, the plates alternate between LA and LB until the right hand end of the lifter row is finished off by a large end plate LC. The third row of liners is again a lifter row, but in this instance, the left hand end commences with a lifter plate LA and so on.

The advantageous relationships achieved under the present construction are illustrated in Figs. 1 and 2. Thus, by off-setting alternate rows of lifter liners so that the pad **13** on a plate LA, Fig. 1, is aligned with the space of a plate LB in the next lifter row, the ledges as **15** and **18** account for a tortuous path for the material being ground up as indicated by the dashed arrows in Fig. 1. In this manner, the fines are gradually allowed to move and sift from the "high" part of the charge toward the bottom of the mill or "toe" of the charge where there occurs highly effective impact grinding as will be explained. This flow is not straight through: to the contrary, it is a divided flow allowing a substantial amount of fine attrition crunching to occur in the conveyor channels under the influence of grinding media rotating on their own axes in the conveyor channels which are continuous along the length of the mill. This, together with similar action of the grinding media supported by the lifter pads, represents secondary rolling grinding within the mill, but the primary grinding or break-up of the charge is due to an effective impact of the grinding media at the toe of the charge near the bottom or to one side of the mill, accomplished in a manner now to be explained.

Referring to Fig. 2, it will be observed that the width of the liner plates in each instance is such as to allow a substantial number of the grinding media to repose in side by side relationship on the elevated surface of the projecting pads or blocks on the lifter plates. In other words, the wear surfaces WS presented by the conveyor plate, and the wear surfaces presented by the lifter pads are of a width equal at least to the combined diameters of several of the grinding media. The net effect of this is that the leading edges of the lifter pads

as 13 and 17, which are angled substantially normal to the wear surfaces WS, push ahead the grinding media within the long channels defined by the conveyor plates.

For convenient reference, the direction of rotation of the mill in Figs. 1 and 2 is assumed to be that of a clockwise direction indicated by the arrow CR. This pushing effect prevails until the force of gravity overcomes the centrifugal force of the mill, and this can be considered as occurring at the top crest of the grinding media mass. When the crest is reached, and the point of the crest will of course depend upon the speed of the mill, the grinding media take flight inward toward the central axis of the mill as indicated by the flight arrows F in Figs. 1 and 2.

Thus it will be seen that there is no backsliding or slippage of the grinding media R until the crest is reached, and as a consequence of this the grinding media tumble and fall down toward the toe of the charge near the bottom of the mill with a tremendous impact on the charge at the toe. This impact on the charge at the toe of the mill represents the primary comminuting force. It should be here pointed out that for purposes of simplicity all the levels of grinding media present in the mill are not illustrated in Figs. 1 and 2. In actual practice, the mill is approximately forty-five percent full of grinding media, and hence there will be various loop flights F characterizing each successive level of grinding media considered as levels between the shell 11 and the central axis of the mill. When the top or outer shell takes flight in the manner illustrated in Figs. 1 and 2, it influences all succeeding rows, and as a consequence of this there is no so-called quiet center of idle media R which can be observed in mills which employ wave-top liners. In other words, all of the rods or balls in the present instance are effectively working either by impact due to flight or as a result of rolling on the liners or on one another.

In Figs. 5 to 9 there are illustrated aspects of a commercial form of installation that has proven eminently satisfactory in use, and to further facilitate an appreciation of the sort of dimensions that can be involved in installations of this kind, it is to be pointed out that Fig. 5 represents a plan view on scale of a complete installation for a commercial ball mill. The long dimension C indicated in Fig. 5 is that of the internal circumference of the shell of the commercial mill and this dimension is 29'–10.1424". The short dimension A in Fig. 5 is the axial length of the mill shell and this dimension is 9'–0". As in the embodiments described above, the assembly illustrated in Fig. 5 is made up of alternating rows of lifter plates and conveyor plates. Thus, half of the total rows of lifter plates consist of two plates 30 and 31 which have sloped edges 30E and 31E, Fig. 6, which in the installation are abutted as shown in Fig. 5. It is found that this type of abutment results in less wear at the division in comparison to a straight division.

Each of lifter plates 30 and 31 is provided with a pair of full dimension lifter pads 35, and the areas where these plates are abutted are cast with truncated half lifter pads 35H. The pads or blocks 35 are spaced as in the foregoing embodiments described above to provide depressed feeder ledges 37 between the lifter pads. The pads and ledges have equal area dimensions, and the pads are wide enough to support several of the grinding media in side-by-side relation. Inasmuch as the assembly will of course be circular within the shell, the long edges of the plates 30 and 31 are sloped at 30S and 31S as shown in Fig. 6, and these plates are formed with openings 38 enabling fastening studs or bolts to be set therein to secure the liner plates 30 and 31 to the shell of the mill.

It will be noted in Fig. 5 that the lifter pads in successive rows of lifter plates are off-set to account for the advantageous cross-flow of pulp as explained above. Consequently, the remaining rows of lifter liners alternate among the rows consisting of the lifter plates 30 and 31, and these remaining rows consist of lifter plates 40 and 41, Figs. 5 and 8. The pads or lifter blocks 45 of the plates 41 and 42 are positioned in alignment with the ledges 37 of the lifter plates 30 and 31, and the depressed ledges 47 between the pads 45 are aligned with the lifter pads 35. It will be recognized further that whereas a lifter row represented by the plates 30 and 31 is terminated at both ends by lifter pads, the next adjacent lifter row is terminated at its end by ledges 47. Moreover, whereas the plates 30 and 31 are cast with half lifter pads 35H at their abutted edges, the plates 40 and 41 are cast at their abutted edges with half ledges 47H, Fig. 5. The assembly is also cast at two points with conventional holes H1 and H2 that will be closed by caps.

The rows of conveyor liners, Fig. 5, also consist of two plates 50 and 51, and these plates are butted at sloped edges S. It will be further observed that by having the plates in the several rows abutting at sloped edges, there is no continuous break. The conveyors 50 and 51 are plain, that is, the wear surfaces WS, Fig. 9, thereof are uninterrupted for the full length. These wear surfaces WS will lie in the plane of the exposed surfaces of the ledges 37 and 47 of the lifter plates.

The mill equipped with the liner assembly illustrated in Fig. 5 is one that operates at approximately 20 r.p.m which represents about 76 percent of the critical speed of the mill. It was mentioned above that mills of this kind are actually filled with grinding media to approximately 45 percent of their volume. This load coupled with the speed of the mill makes it possible to have the lifter pads or blocks projecting above the adjacent depressed ledges and wear surfaces by approximately one-third the diameter of the maximum-sized grinding media used in the mill, and of course this height differential prevails throughout the grinding media mass in respect of successive concentric shells of grinding media. Thus, were it not for the speed of the mill and the load of the grinding media, the most advantageous projecting distance for the lifting pads would be the radius or half the diameter of the maximum-sized grinding media to assure pushing of the grinding media and prevent backsliding but as explained, operating conditions make it possible to reduce this distance to one-third the diameter of the maximum-sized grinding media. However, even at the slow speed of 20 percent of critical speed, where considerable cascading and backsliding has heretofore been encountered under the prior practices (cascading and backsliding are even observed at 75 percent critical speed) there is no observable cascading or backsliding under the present practice where the lifter pads project for one-third the diameter of the maximum sized grinding media. It might also be mentioned that in most instances a mill of the kind under consideration is filled with 75 percent of the maximum-sized grinding media, three or four inches in diameter for example. Extending this illustration, 15 percent of the grinding media are represented by diameters of 2½ inches, and the remaining amount of 10 percent is represented by 2 inch diameter grinding media. This is simply for purposes of explanation and represents the average practice.

Thus it will be seen from the foregoing that the present arrangement of liners accounts for highly effective impact and rolling or attrition grinding. Ineffective slippage and uncontrolled cascading is prevented by the leading shoulders of the lifter pads pushing ahead the grinding media until the apex or crest point is reached. The spaced pads which provide the circumferential or cross feeder channels, through which the dashed arrows in Fig. 1 are drawn, account for separation and some slowing down of the back pulp flow down the mill. The pulp or charge fines escape easily but the coarse charge ma-

terial remains behind in the longitudinal conveyor channels where the grinding media are effective with a rolling action, and in this connection it will be recognized that inasmuch as the full width of the liner plates are used in providing the lifter pads or in affording the depressed conveyor channels, there is plenty of room for effective rolling action of the grinding media. Moreover, and due to the ample or generous lifter pad surfaces, any hammering or peening effect of the falling grinding media is distributed over a wide area so that consequent damage is virtually nil. There is additional impact crushing due to the occurrence of grinding media rolling off the thick lifter pads onto the depressed wear surfaces WS afforded by the conveyor plates. Hence, while I have illustrated and described preferred embodiments of my invention, it is to be understood that these are capable of variation and modification, and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. In a grinding mill of the kind described having a rotatable shell and which is to contain grinding rods having predetermined diameters, and the charge to be comminuted by the grinding rods: alternating rows of dissimilar shell liners secured for rotation with the shell, certain ones of the liner rows presenting depressed wear surfaces defining elongated conveyor channels each of a width substantially equal to the combined diameters of several of the grinding rods to enable at least several of the grinding rods to be confined therein in side-by-side relation, said channels being uninterrupted substantially from one end of the mill to the other, and the remaining liner rows having raised lifter pads that are spaced apart one from another along the length of those rows, said lifter pads having wear surfaces spaced above said depressed channel wear surfaces by a distance at least one-third the diameter of the maximum sized grinding rods used in the mill, the width of the lifter pad wear surfaces being at least the combined diameters of several of the grinding rods to enable at least several of the grinding rods to be supported thereon in side-by-side relation, said remaining liner rows having depressed ledges presenting depressed wear surfaces between and separating the lifter pads by distances substantially equal to the length of the lifter pads and which are substantially coplanar with the first-named depressed wear surfaces enabling the comminuted charge to move freely in a cross-flow past said pads and into the conveyor channels.

2. A grinding mill according to claim 1 wherein the rows of liners having raised lifter pads are off-set along the length of the mill whereby a lifter pad in one lifter liner row is located opposite a depressed ledge in the next adjacent lifter liner row.

3. In a grinding mill of the kind described having a rotatable shell and which is to contain grinding rods having predetermined diameters, and the charge to be comminuted by the grinding rods: alternating rows of dissimilar shell liners secured for rotation with the shell, one liner row comprising a plurality of conveyor plates of substantially the same thickness aligned in end-to-end relation and presenting a depressed wear surface defining an elongated conveyor channel of a width substantially equal to the combined diameters of several of the grinding rods to enable at least several of the grinding rods to be confined in such channel in side-by-side relation, said channel being uninterrupted substantially from one end of the mill to the other, and the next adjacent liner row comprising a plurality of lifter plates assembled in end-to-end relation and in the assembly having raised lifter pads that are spaced apart one from another along the length of that row, said lifter pads having wear surfaces spaced above the depressed wear surface of said channel by a distance at least one-third the diameter of the maximum-sized grinding rods used in the mill, the width of the lifter pad wear surfaces being at least the combined diameters of several of the grinding rods to enable at least several of the grinding rods to be supported thereon in side-by-side relation, said adjacent liner row having depressed ledge portions presenting wear surfaces between and separating the lifter pads, and said ledge portions being substantially of the same thickness as the conveyor plates so that the wear surfaces of said ledge portions are substantially coplanar with the depressed wear surface of said channel enabling the comminuted charge to move in a cross-flow past said pads and into the conveyor channel.

4. A liner construction for a grinding mill of the kind which includes a generally cylindrical shell containing grinding rods having predetermined diameter for comminuting a charge by impact and relative rotation between said grinding rods produced by rotation of said shell, said liner comprising, a plurality of conveyor liners arranged in longitudinally extending rows and a plurality of lifter liners arranged in longitudinally extending rows and alternating circumferentially with the rows of said conveyor liners, said lifter liners having pads projecting radially inwardly for lifting said grinding rods during rotation of said shell and depressed ledges substantially coplanar with the wear surfaces of the conveyor liners, said projecting pads being longitudinally spaced from one another by said depressed ledges to define channels therebetween of substantially the same longitudinal extent as the projecting pads for the passage of ground material between conveyor rows, and each of said rows of conveyor liners having a width which is greater than the combined diameters of several of said grinding rods, whereby several of said grinding rods are freely rotatable within each of said rows of conveyor liners to effect grinding therebetween during rotation of said shell.

5. A liner construction as defined in claim 4 wherein the pads in one row of said lifter liners are longitudinally offset from the pads in the next adjacent row of said lifter liners.

References Cited in the file of this patent

UNITED STATES PATENTS

221,548	Golding	Nov. 11, 1879
688,229	Hundeshagen	Dec. 3, 1901
2,268,661	Kennedy	Jan. 6, 1942
2,670,140	Douglas	Feb. 23, 1954

FOREIGN PATENTS

166,073	Austria	June 10, 1950
272,033	Switzerland	Mar. 1, 1951