Aug. 1, 1939. R. S. BUTLER 2,168,086

MILL

Original Filed Dec. 31, 1934 2 Sheets-Sheet 1

Fig. 1.

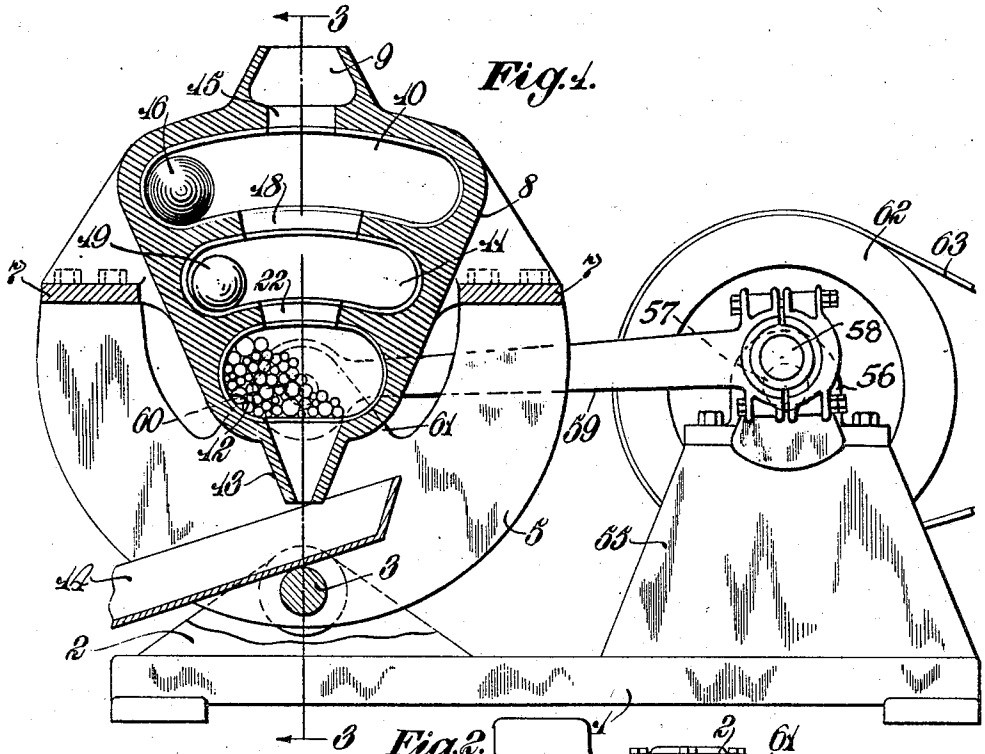


Fig. 2.

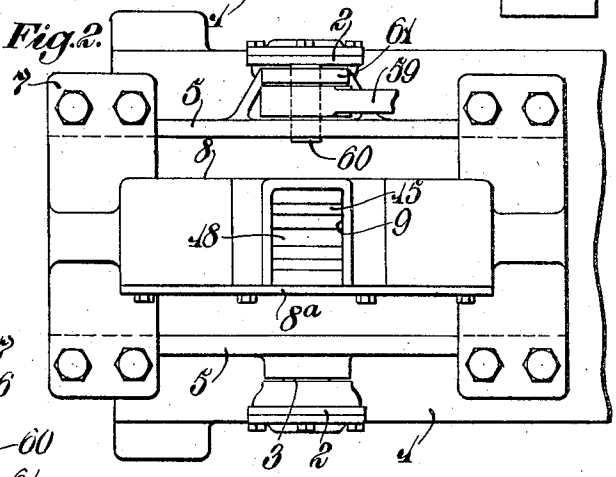
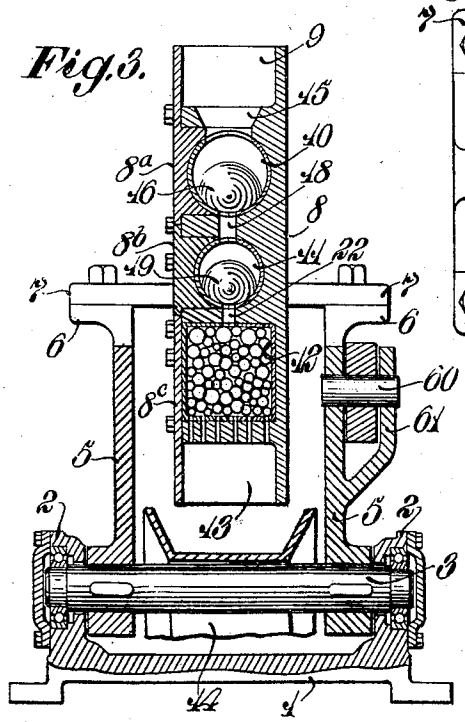


Fig. 3.



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Fig. 4.

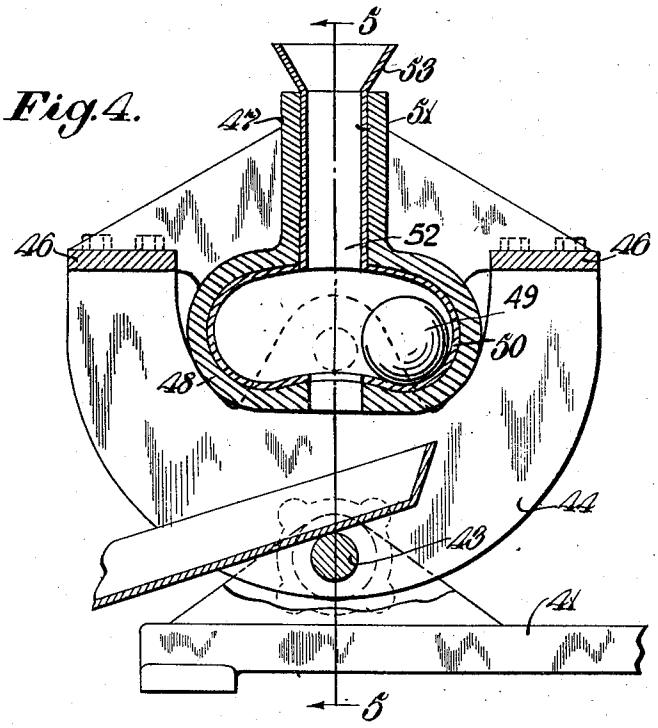
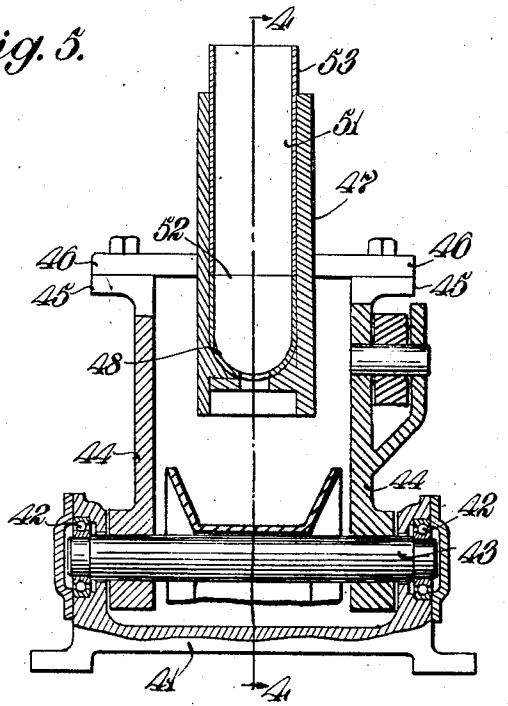


Fig. 5.



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UNITED STATES PATENT OFFICE

2,168,086

MILL

Robert S. Butler, Santa Monica, Calif., assignor to Sullivan Machinery Company, a corporation of Massachusetts

Application December 31, 1934, Serial No. 759,904
Renewed March 14, 1939

11 Claims. (Cl. 83—9)

My invention relates to size-reducing mills, and more particularly, in one phase, to apparatus for effecting sequential crushing and pulverizing in a single unit, although means for accomplishing each result separately constitute other aspects of my invention, and I have shown in this present application an embodiment of one phase of the invention in a single-stage crusher.

An object of my invention is to provide an improved size-reducing mill. Another object of my invention is to provide an improved material-crushing and pulverizing apparatus. A further object of my invention is to provide an improved apparatus for reducing rock, ore, retort residues, coal or other material from pieces of relatively large size to relatively much smaller size, indeed to the minimum commercial sizes, if desired. Still another object of my invention is to provide material-size-reducing apparatus requiring a relatively small amount of power for its operation. Yet another object of my invention is to provide an improved material-reducing apparatus of very simple construction, of light weight compared with presently marketed apparatus for either rock crushing or pulverizing of comparable capacity, and requiring less power than such present commercial devices of comparable capacity. Still another object of the invention is to provide an apparatus which will perform the operations of secondary crushing and pulverizing in a unit not larger than the smallest present commercial unit for performing either operation at an equal rate. Yet another object is to provide a size-reducing mill which will, by impact and attrition, both very efficiently applied, through the use of the kinetic energy of relatively movable size-reducing means, provide a production of reduced material which will be extremely high considering the size of the apparatus employed, and its power consumption.

Heretofore various efforts have been made to produce mills in which a reducing chamber has imparted to it movements frequently reversed in direction, so as to endeavor to effect material-size-reduction by the action of an enclosed quantity of crushing media upon material enclosed with said media in the size-reducing chamber. All such previous attempts with which I am acquainted have wholly failed to produce such a degree of satisfactory operation as to bring them into substantial commercial use. My present invention constitutes a marked improvement over all mills of the prior art with which I am acquainted, possessing any color of analogy to it, though this present invention does not possess certain of the advantages of the inventions in rocker mills which are covered by other applications for Letters Patent which I am filing of even date herewith.

In the accompanying drawings, in which two forms which, in different aspects, my invention may assume in practice, are shown for purposes of illustration—

Fig. 1 is a view, partially in side elevation and partially in central vertical section, through a plural-stage material-reducing mill constructed in accordance with one illustrative embodiment of the invention.

Fig. 2 is a top plan view of the mill shown in Fig. 1, with parts omitted.

Fig. 3 is a vertical section on the plane corresponding to the line 3—3 of Fig. 1, showing a transverse section through the mill.

Fig. 4 is a vertical section on the line 4—4 of Fig. 5, showing a modified, single-stage embodiment.

Fig. 5 is a central vertical section on the plane corresponding to section line 5—5 of Fig. 4.

Referring to the drawings, and first to Figs. 1 to 3, it will be noted that a base 1 provides a pair of upstanding brackets 2, 2 at the opposite sides thereof, and these brackets support, in suitable bearings, a transverse shaft 3. The shaft 3 supports and has herein keyed thereto a pair of upstanding, somewhat semi-circular or lyre-shaped frame elements 5, 5, and these at their tops are provided with flanges 6, 6 providing a support for cooperating flanges 7, 7. The flanges 7, 7 support a size-reducing chamber member 8, which is herein shown as of unitary construction save for the removable side plates 8^a, 8^b, 8^c, which are provided so that liners may readily be inserted and replaced if desired. The member 8, in the embodiment of the invention shown in Figs. 1 to 3, provides a series of chambers 9, 10, 11, 12, the chamber 9 being an initial material-receiving chamber and being adapted to be connected in any suitable manner in communication with a pivotally or flexibly mounted material-delivery or filler spout or the like, not shown. 10 is a primary crushing chamber; 11 a secondary crushing chamber, herein below the chamber 10 and nearer the axis of the shaft 3. 12 is a pulverizing chamber. Desirably, a spout 13, arranged herein near the middle of the lower side of the pulverizing chamber 12, is adapted to deliver the completely processed material into a launder or chute 14.

As above stated, the chamber 9 is adapted to have communication effected therewith by any

suitable means, as, for example, by a pivoted filler spout through which a continuous feed of material to be ground may be secured, or by any arrangement of parts such that through periodic deposit of material in the chamber 9 the material to be crushed is delivered in adequate quantity and at an appropriate rate for reduction in the several chambers 10, 11, 12. An opening 15 connects the receiving chamber with the primary crushing chamber 10. The latter is somewhat elongated and contains initially a free-moving crushing means, herein in the form of a ball 16 of relatively large size and heavy weight. It will be understood that a spherical shape is not imperative, and that the size and weight of this free crushing means may vary with the nature of the material to be crushed, but as a generality the free crushing means may advantageously be of comparable diameter to the size of the largest pieces to be introduced into the mill. A portion of the bottom of the chamber 10 may be constructed to permit the passage of initially reduced material from the chamber 10 into the chamber 11, the bottom wall of the chamber 10 herein being shown to be traversed by a single longitudinally extending slot 18 of appropriate width, and extending longitudinally of the chamber near the central portion thereof; but obviously a series of holes of appropriate size, or a renewable gridwork, or any other suitable means for providing suitably retarded passage of the material from chamber 10 to chamber 11, may be resorted to.

The chamber 11 which receives the partially reduced material from chamber 10 receives the material from the latter in the form of a mixture, the largest pieces of which represent the minimum satisfactory reduction in the first chamber, and the smallest fragments of which may be to a considerable extent reduced almost, if not wholly, to the utlimate desired size, with a very substantial quantity of material in an intermediate stage of size-reduction. Chamber 11 herein contains a free crushing means, also shown as a ball, numbered in this case 19, although obviously other shapes of reducing elements may be employed. In this chamber the ball size substantially exceeds the diameter, so to speak, of the largest fragments capable of passage through the opening 18. Chamber 11 is herein shown as shorter than the chamber 10, for reasons which will later be explained. A variable chamber length may be accomplished, within limits, by the insertion of liners of various thicknesses in the ends of any chamber. The chamber 11 is provided, herein adjacent its center, with discharge means 22 through which adequately crushed material may attain access to the chamber 12. As explained with respect to the opening 18, any suitable means of providing a properly controlled opening 22 may be resorted to, and any appropriate means may be resorted to to retard and control passage of reduced material through the opening, to insure adequate reduction in the second-stage chamber 11.

Chamber 12 contains, in the illustrative embodiment shown, in which this chamber is of substantial longitudinal dimension, quite a quantity of a size-reducing medium, which may advantageously assume the form of a mass of balls of mingled sizes ranging from perhaps half an inch or more in diameter down to a sixteenth of an inch, although it will be understood that reducing medium sizes, as described, are not necessarily definite and will vary widely under different circumstances. Discharge of the material, which will be thoroughly pulverized in the chamber 12, through the spout 13 will be controlled by any suitable grid, screen or sieve arrangement; it being understood that adequate strength and wearing qualities may be attained by reason of the fact that it is unnecessary to preclude the passage of any except completely reduced material through at this stage, since by the use of an appropriate classifier such large particles as escape with the fully reduced material may be separated out for re-grinding and pulverizing in the mill. The mill described is obviously adapted for wet or dry grinding and for a very wide range of material, from the hardest rock to the most friable substances.

In the species of the invention shown in Figs. 4 and 5, the essential difference resides in the fact that a single-stage mill primarily adapted for crushing is shown. In that embodiment of the invention a base 41 supports, in suitable bearings 42, a transverse shaft 43 supporting upstanding members 44 adjacent each end thereof, which members provide platform 45 at their upper ends adapted to support the lateral bracket members 46 of a crusher chamber casing 47.

The crusher chamber casing is, in this embodiment, of the single-stage crusher type and contains only a single chamber 48 containing a free crushing means 49, herein illustrated as a single ball. A suitable liner 50 is enclosed in the casing, and a suitable supply passage 51 opens through the top of the casing, opening at its lower end through a passage 52 approximately midway between the ends of the chamber 48 into the latter, and at its top being provided with a chute or mouth portion 53 with which a suitably pivoted discharge member of a feeding apparatus, not shown, is intended to communicate. In both forms of the invention there is provided suitable means for oscillating the size-reducing chamber member, but the details of this construction are fully illustrated only in connection with Fig. 1. It will be noted that the bed frame 1 carries upstanding block or support members 55 thereon, supporting pillow blocks 56 in which a crankshaft 57 is suitably journaled. The crank pin 58 of this shaft is connected by connecting rod 59 with a wrist pin 60 supported between a bracket arm 61 and one of the side frame members 5. The shaft 57 is provided with suitable driving and energy-storing means, herein combined in a heavy-rim flywheel 62 which may be driven by any suitable driving means, as, for example, the belt 63.

In connection with both forms of the invention, the following factors are noteworthy. Insofar as the crushing functions and the means for accomplishing them are concerned, it will be observed that these are largely effected by impact; this impact being provided between a free-moving crushing means and a positively moved crushing means, through whose movements there is imparted motion to the free-moving crushing means such that at times the latter moves with the former and at times moves in the opposite direction to the former, with the result that impact occurs twice in each complete cycle of movement of the positively-moved member. The lengths of the chambers are varied to effect the functioning described, and it will be found that disregarding the angularity of the crankshaft effect and the effect of the oscillating motion of the chamber members, it is possible, where a free size-reducing means is of stable outline, to

accomplish the desired result of obtaining the advantage of maximum impact by fixing the chamber length more or less in accordance with the following formula: $B+1\frac{1}{2}S+1\frac{1}{2}M$, in which B is the dimension along the path of movement of the chamber in which the freely-moving size-reducing means is contained, of such size-reducing means; S is equal to the total travel, from end to end of the path of movement, of a point midway between the top and bottom of the particular chamber in question; and M is the maximum dimension of the unbroken material entering the particular chamber being figured. With reference to the pulverizing portion of the device, it will be understood that because of the, so to speak, fluidity of the size-reducing charge, greater deviation from a given formula may be expected, which deviation will be furthered by reason of the possible substantial variation in the quantity of the free pulverizing charge contained in the pulverizing chamber. However, this is compensated for by the fortunate fact that relatively wide variations in the quantity of pulverizing material can take place without great sacrifice of efficiency. It should, however, be noted that the chamber height, particularly in the pulverizing chamber in multi-stage mills or in purely pulverizing mills, should not exceed such a dimension that at two points at least in each cycle of the chamber member movement, the chamber will not be completely filled, throughout a substantial portion of its length, from top to bottom and side to side by the mingled charge of free-moving pulverizing medium and particles of material to be pulverized; but such proportioning of the chamber feed rate can be controlled as more fully explained in my copending application Serial No. 759,902 relating to improvements in single-stage pulverizers, which I am filing of even date herewith.

The employment of liners in all the stages will be obvious, and for such liners chrome steel is a highly satisfactory material. Solid or hollow balls, or other free-moving crushing means may be employed as may be required by the hardness and friability of the material to be crushed. The stroke of the several chambers will obviously vary directly with their radial distance from the axis of oscillation, and will also vary with the throw of the crankshaft **57**. In the design of the device, since kinetic energy is made available to a maximum degree, the force of blow necessary for each stage will first be determined. The ball sizes best combining the necessary size and weight requirements will then be selected. With the maximum force of blow for each stage determined, the speed of revolution of the crankshaft and the throw of the crank will be determined to provide the necessary velocity to insure the desired kinetic energy. Preferably, the characteristics for the first crushing stage will be determined first, and thereafter appropriate dimensions for subsequent crushing stages will be worked out within the limits established by the dimensions of the primary crushing chamber. The pulverizing chamber, or a plurality of them, should more be necessary, may be last determined, and because of the wide range of ball sizes possible and the wide range of normal ball position, great flexibility of design is permitted.

For further details with respect to design principles, if desired, reference may be had to my copending application Serial No. 759,902, referred to above, but it will be evident from the foregoing description that I have provided an oscillating mill having a chamber-providing member pivotable about an axis below the chamber or chambers and having feed therein effected from top to bottom by gravity, with the tendency to pass from the zone of action of more powerful forces to the zone or zones of forces of a lower order somewhat offset by the centrifugal action within the chambers. It will be understood that the invention may be incorporated, from certain aspects, in single or multi-stage mills, in crushers or pulverizers, or in combinations of the same.

It is desirable to note that in the event that less reliance need be placed upon sharpness of impact, and so on velocity of relative movement, chamber and contents proportions may be modified, and by reduction in chamber length or increase in volume of chamber contents—either by increase of crushing or pulverizing medium dimension or quantity or by increase of material to be processed—the factor of sharp impact may be diminished and any mode of operation, to and including absorption of all the energy of the motion of the internal mass at or prior to dead center position, can be effected.

While in this application I have specifically described two forms which my invention may assume in practice, it will be understood that these forms are shown for purposes of illustration, and that the invention may be further modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In a mill, a base, an oscillating member pivotally mounted on said base and provided with a size-reducing chamber radially spaced from the pivot of said member and above said pivot and elongated in the direction of its oscillation and of substantially uniform cross sectional area at substantially all points between its end portions on planes including the axis of pivotal movement of said oscillating member, means for oscillating said member, size-reduction means loosely enclosed in said chamber and adapted substantially to fill the opposite ends of the latter from top to bottom on alternate movements of said chamber, and a continuously open feed connection with the top of said chamber through which the same may be supplied with material to be reduced during oscillation of said chamber.

2. In a size reducing mill, a chamber forming member oscillatable through a relatively small arc in vertical planes about a horizontal axis disposed adjacent the bottom thereof, said member providing an arcuate chamber elongated, but not annular, in substantially the direction of oscillation of said member and conforming substantially in curvature to an arc of a circle struck from said axis, said chamber having end walls for reversing the direction of movements of the contents thereof positively, means for so oscillating said member, and means for feeding material to and discharging material from said chamber during oscillation.

3. In a size-reducing mill, a base, a pivoted member thereon having extending through the upper end thereof a constantly open filler passage, below the latter an elongated reducing chamber, and below said reducing chamber but still above the lower end of said member a pivot, said elongated reducing chamber of relatively uniform cross-sectional dimension on planes including the axis of such pivot, means for oscillating

said member on said pivot, and a charge of material-reducing bodies in said chamber.

4. In a size reducing mill, a base, a pivoted member thereon having extending through the upper end thereof a constantly open filler passage, below the latter an elongated arcuate reducing chamber of substantially uniform cross section between the end portions thereof, and below said reducing chamber a pivot, means for oscillating said member on said pivot to cause said chamber to move in an exclusively downwardly concave limited arcuate path of similar curvature to its own, and a charge of material-reducing bodies in said chamber.

5. In a mill, a chambered rocker element pivotable about an axis adjacent the bottom thereof for swinging movement transverse to a vertical plane including such axis, said element having therein at least two chambers elongated in their direction of swing and approximating uniformity of cross section throughout their respective lengths between their end portions and differently radially spaced from said axis and each having in the mid-position of said rocker element its opposite ends both lower than its central longitudinal portion, material size-reducing media in said chambers, means for introducing material into the upper chamber, passage means for interconnecting said chambers, and means for discharging the material reduced in size from the lowest chamber.

6. In a mill, a chambered rocker element pivotable about an axis adjacent the bottom thereof, said element providing at least two arcuate chambers concentrically arranged with respect to said axis but struck on different radii, material size-reducing media in said chambers, passage means for connecting said chambers, means for introducing material into one of said chambers, and means for discharging the material reduced in size from the lowest chamber.

7. In a mill, a chambered rocker element pivotable about an axis for like oscillatory movements in opposite directions from a median position, said element provided with an arcuate chamber therein whose ends are lower than its longitudinal center when said element is in its mid-position of pivotal movement and which has substantially uniform cross section throughout the major portion of its length, a grinding medium in said chamber, and means for rapidly oscillating said element to effect coaction in alternation between the opposite chamber ends and said grinding medium, in a size-reducing operation.

8. In a mill, a chambered rocker element pivotable about an axis, said element providing a plurality of concentrically arranged arcuate chambers variously spaced above said axis, each of said chambers elongated in the direction of its pivotal movement and of substantially uniform cross sectional area at substantially all points between its end portions on planes including the axis of pivotal movement of said rocker element, grinding media of different sizes in said different chambers, the chamber with the largest grinding media most remote from said axis, means for supplying material to be reduced in size to said last mentioned chamber, means for discharging material from the chamber nearest said axis, means for interconnecting said chambers for the passage of material between them, and means for oscillating said element to cause opposite arcuate movements of said chambers above said axis and along their respective arcs.

9. In a mill, a chambered rocker element pivotable about a horizontal axis, said element having an arcuate downwardly concave chamber therein whose ends are lower than its longitudinal center when said element is in its mid-position of substantially uniform cross section throughout the major portion of the distance between its ends and confined in all positions of said rocker element to positions at one side of a horizontal plane including the pivotal axis of said rocker element, a grinding medium in said chamber, and means for swinging said element, through an arc substantially bisected by a vertical plane including such axis, between extreme positions in each of which said chamber is cut by such plane.

10. In a mill, a chambered rocker element pivotable about an axis, said element provided with a downwardly concave arcuate crushing chamber therein whose ends are lower than its longitudinal center when said element is in its mid-position of pivotal movement and which chamber is of an arcuate length less than 180° and has ends for reversing the movements of a charge therein, size-reducing means including at least one size-reducing element of relatively large diameter in said chamber, means for oscillating said rocker element through such a range that said chamber is at all times downwardly concave to effect a size-reducing action between said size-reducing means and the opposite ends of said chamber in alternation, and means for introducing material into said chamber and discharging material therefrom during oscillation.

11. In a mill, a chambered rocker element pivotable about a horizontal axis, said element providing a plurality of concentrically arranged arcuate chambers spaced above said rocker axis and of similar arcuate angular extent and arranged in a common sector whose bounding radii each have a point in the pivot axis as a center, means for conducting processed material between said chambers and from the one nearest said pivot, and power means for rapidly oscillating said rocker element to move said chambers to bring their respective opposite extremities substantially equal angular distances at opposite sides of a vertical plane including said horizontal axis.

ROBERT S. BUTLER.

CERTIFICATE OF CORRECTION.

Patent No. 2,168,086. August 1, 1939.

ROBERT S. BUTLER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 24, for "platform" read platforms; page 4, second column, line 18, claim 9, after "mid-position" insert of pivotal movement and which chamber is; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 30th day of January, A. D. 1940.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)