Aug. 1, 1939. R. S. BUTLER 2,168,090

PULVERIZER

Original Filed Dec. 31, 1934 3 Sheets-Sheet 1

Fig. 1.

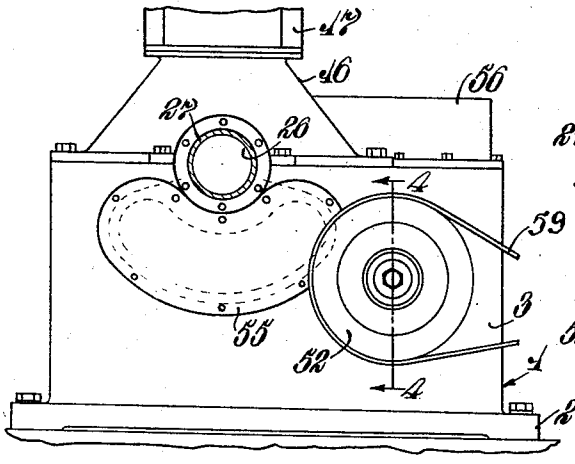


Fig. 2.

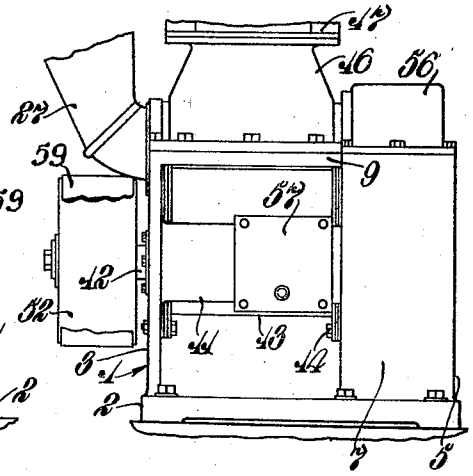


Fig. 3.

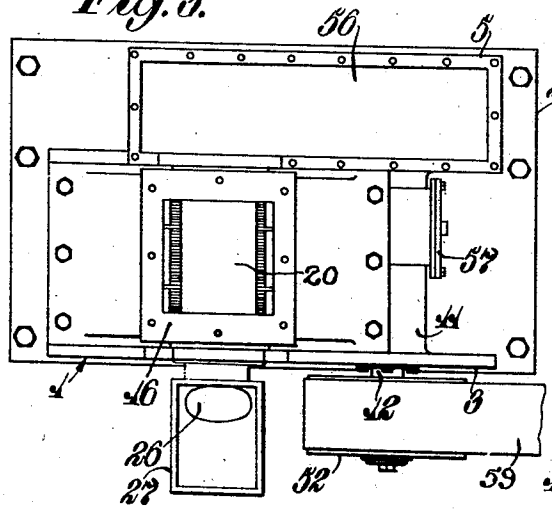
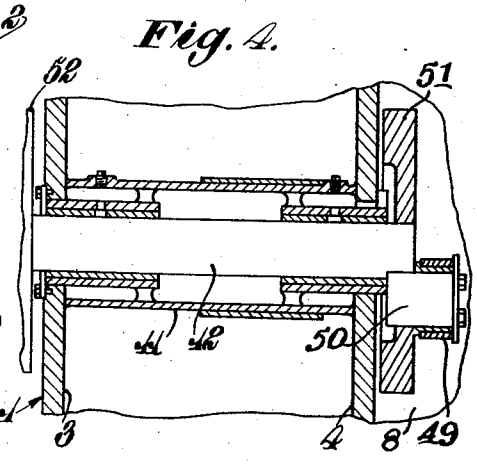


Fig. 4.



Inventor:
Robert S. Butler.
by Louis A. Macrum.
Atty.

Aug. 1, 1939. R. S. BUTLER 2,168,090

PULVERIZER

Original Filed Dec. 31, 1934 3 Sheets-Sheet 2

Fig. 5.

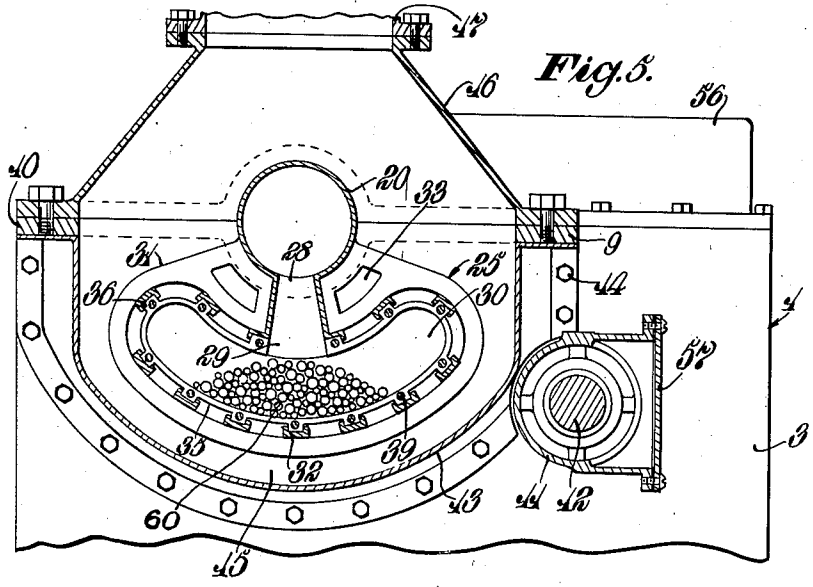


Fig. 6.

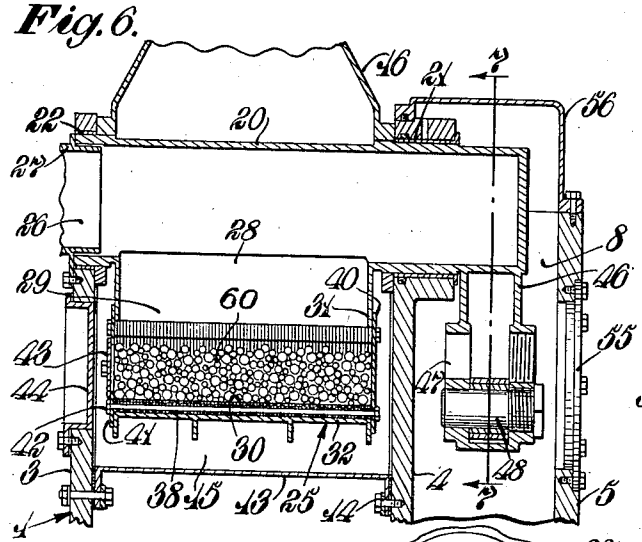


Fig. 8.

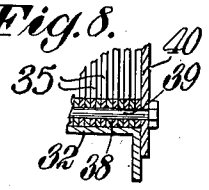


Fig. 9.

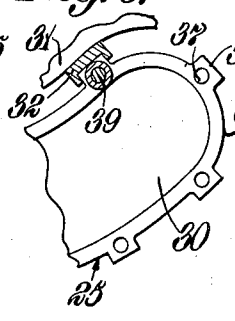
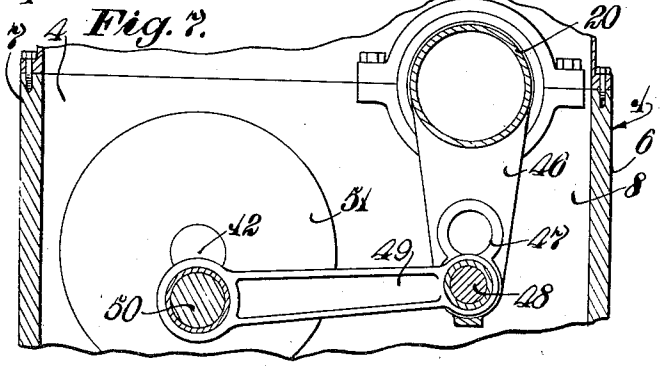


Fig. 10.



Fig. 7.



Inventor:
Robert S. Butler.
by Louis A. Maxson.
Atty.

Aug. 1, 1939. R. S. BUTLER 2,168,090

PULVERIZER

Original Filed Dec. 31, 1934 3 Sheets-Sheet 3

Fig. 11.

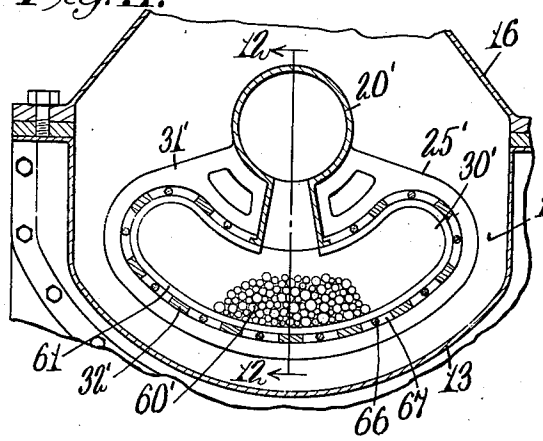


Fig. 12.

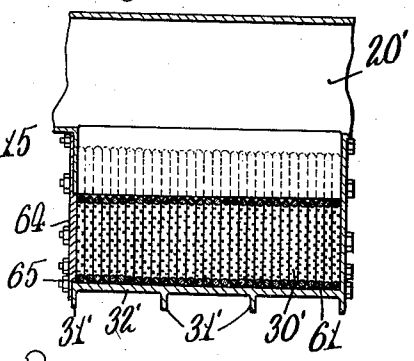


Fig. 13.

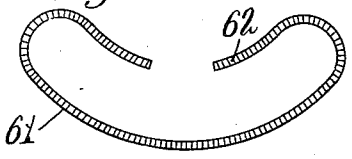


Fig. 14.

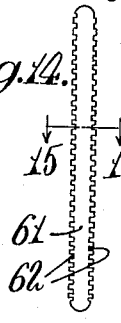


Fig. 15.



Fig. 16.

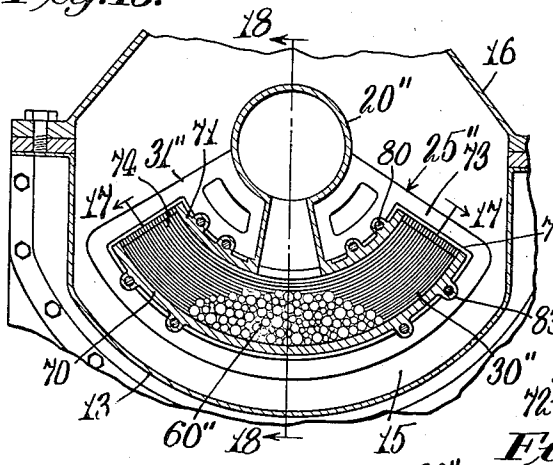


Fig. 17.

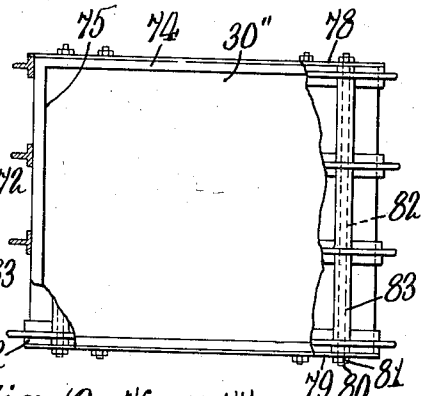


Fig. 18.

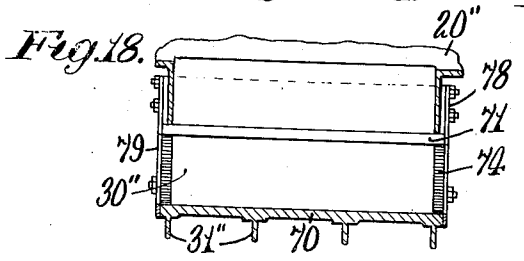
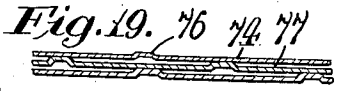


Fig. 19.



Inventor:
Robert S. Butler.
by Louis A. Maxon.
Atty.

Patented Aug. 1, 1939

2,168,090

UNITED STATES PATENT OFFICE

2,168,090

PULVERIZER

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

Application December 31, 1934, Serial No. 759,906
Renewed May 2, 1939

17 Claims. (Cl. 83—9)

My invention relates to pulverizing or fine grinding apparatus, and more particularly to apparatus for reducing materials such as rock, ores, coal, retort residues, etc., from the size to which they may be reduced by the usual secondary crushing operations, to sizes down to minus 200 mesh or finer, as may be desired. Still more specifically, my invention relates to an improved form of grinding chamber for material size-reducing devices of the character disclosed and claimed in certain copending applications which I am filing of even date herewith.

An object of my invention is to provide an improved pulverizing mill. Another object of my invention is to provide an improved pulverizing mill having improved means for the discharge of processed material therefrom. Still another object of my invention is to provide an improved pulverizing mill having an improved pulverizing chamber construction. Yet another object is to provide an improved pulverizing chamber construction providing for the discharge of adequately pulverized material from practically all parts of the peripheral walls thereof in the planes of motion of the material in the chamber. Still another object is to provide an improved pulverizing chamber construction providing for the discharge of adequately pulverized material through the lateral and/or end walls of the chamber, if desired. Still another object is to provide an improved built-up construction for a pulverizing chamber using stamped or otherwise suitably formed laminae, the spaces between which provide for the discharge of pulverized material, and the inner surface of which provides bounding walls for the pulverizer chamber. Yet another object is to provide an improved built-up pulverizer construction in which parallel, concentric, or otherwise closely contiguous bands, strips, or rods, bent or otherwise formed, if desired, to conform to the shape of an element of the chamber wall, form one or a plurality of the bounding walls of a pulverizing chamber, and provide between their mutually adjacent surfaces orifices or vents for the discharge of pulverized material. Still another object is to provide an improved pulverizer in which an oscillating size-reducing chamber is fed with material to be pulverized adjacent the point of minimum movement thereof and in which widely extended material discharge arrangements are provided substantially throughout the area of the walls of said chamber which are most remote from the axis of oscillation thereof. Still another object is to provide an improved pulverizer in which an oscillating pulverizing chamber, provided with a charge of reducing medium freely movable therein and whose movements are reversed periodically by the movements of said chamber, is provided with an improved wall construction such that adequately pulverized material can be discharged throughout the walls against which the mixed contents of reducing medium and material in process of pulverization are presented either by centrifugal force or by virtue of positive movement imparted to the chamber contents by movements of the chamber. Still another object of my invention is to provide an improved pulverizer chamber construction in which the entire wall area, except the sides and that space occupied by the material-feeding orifice, is provided with discharge apertures for pulverized material. Yet another object is to provide an improved pulverizer chamber of built-up construction, in which, in the event of unequal wear, portions of the walls thereof may be replaced while other portions are reused, and in which nuts, threaded rods, washers and stampings constitute the greater portion of the structural elements used in the chamber construction. Still a further object of the invention is to provide an improved grinding chamber construction having improved provision for the reception of material to be ground through one wall thereof, and for the discharge of ground material through a plurality of walls at an angle to the wall through which ingress of material to be ground occurs. Still another object of my invention is to provide an improved pulverizing chamber construction in which the degree of fineness of pulverization may be controlled by variation in the wall structure of the pulverizing chamber, said chamber being provided with walls built up of spaced laminations or other elements between which the distances may be varied by the interposition of separating devices of different thicknesses, or in which, by the use of differently constructed laminae, or other elements presenting narrow surfaces to the chamber cavity, and themselves provided with deformations, local or general, intermediate discharge spaces of variable width may be provided. Yet a further object of my invention is to provide an improved pulverizing device in which a pulverizing chamber having relatively very widely distributed provision for the discharge of adequately processed material, is movable in a space subjected to subatmospheric pressure, or within a space in which, by appropriate means, a pressure lower than that within the chamber is maintained. Another object is to provide an improved pulverizer which

is readily adapted for wet or dry grinding; and a still further object is to provide an improved pulverizing chamber having certain of the peripheral walls thereof and particularly those especially subjected to impact and attrition during the pulverizing process, made up of spaced wall-forming elements each substantially conforming to the complete outline of the bounding wall of the pulverizing chamber, or of elements of similar contour which, while not wholly spaced from each other, yet provide between them appropriate space for the discharge of pulverized material.

Referring to the drawings, in which three illustrative embodiments of the invention are shown for purposes of illustration,

Fig. 1 is a side elevation of a pulverizing apparatus constructed in accordance with an illustrative form of the invention, with parts broken away.

Fig. 2 is an end view, with a portion of the material-removing mechanism and the supply chute broken away, of the apparatus shown in Fig. 1.

Fig. 3 is a top view of the apparatus shown in Figs. 1 and 2, with parts omitted.

Fig. 4 is an enlarged vertical section on a plane corresponding to the line 4—4 of Fig. 1.

Fig. 5 is a vertical longitudinal section through the pulverizing chamber and associated parts.

Fig. 6 is a vertical transverse section through the pulverizing chamber and the chamber in which the driving apparatus is enclosed.

Fig. 7 is a vertical longitudinal section on the line 7—7 of Fig. 6, showing the chamber driving means.

Fig. 8 is a fragmentary sectional view on a larger scale than Fig. 6 showing a detail of chamber wall construction.

Fig. 9 is another detail view showing one of the wall-forming laminae and the means of mounting the same.

Fig. 10 is an end elevational view of one form of chamber-wall-forming element.

Fig. 11 is a vertical longitudinal section through a differently constructed pulverizing chamber and associated parts.

Fig. 12 is a fragmentary central vertical section through the chamber shown in Fig. 11, the section being taken on the plane of line 12—12.

Fig. 13 is a side elevational view of one of the wall-forming elements employed in the chamber construction of Figs. 11 and 12.

Fig. 14 is an end elevational view and Fig. 15 is a cross section through a portion of the wall-forming element of Fig. 13, Fig. 15 taken on line 15—15 of Fig. 14.

Fig. 16 is a vertical longitudinal section through a still differently constructed pulverizing chamber, and its associated parts.

Fig. 17 is a developed section, with parts shown in full upon the line 17—17 of Fig. 16.

Fig. 18 is a fragmentary sectional view upon the plane of the line 18—18 of Fig. 16, through the feed passage and pulverizing chamber of Figs. 16 and 17.

Fig. 19 is a fragmentary sectional view on a larger scale than Fig. 16, showing a detail of chamber wall construction of the structure illustrated in Figs. 16 to 18 inclusive.

Referring to the drawings and for the present to Figs. 1 to 10 thereof, it will be observed that, in the illustrative embodiment shown in those figures, a frame, generally designated 1 and which comprises a base portion 2 and three upright walls 3, 4 and 5, is provided. The walls 4 and 5 are connected by end wall portions 6 and 7 to provide a chamber 8 in which the driving apparatus is enclosed in part. The walls 3 and 4 are connected by transversely extending top members 9 and 10, which rigidly space them, and are further connected by a hollow sleeve-like member 11 which provides a housing for a transversely extending crankshaft 12. A suitable relatively light pan or bottom enclosure member 13 is bolted, as at 14, to the opposite side walls 3 and 4 and provides a rocker receiving chamber 15. The top transverse members 9 and 10 support an upwardly tapering cover member 16 which supports at its top, apparatus of which but a fragment is shown at 17, which is used to conduct away the pulverized material. Reference may be made to my application Serial No. 759,902, filed of even date herewith for one illustrative arrangement for this purpose. Upon a hollow transverse shaft 20 suitably supported in bearings 21 and 22 in the frame walls 4 and 3, there is supported a pulverizing-chamber-providing member, generally designated 25, herein in the form of a rocker. The hollow shaft 20 has at one end free communication with the inner passage 26 of a stationary supply chute or hopper 27, and the lower wall of the hollow shaft member 20 is cut away, as at 28, to provide an opening into a gradually expanding radial feed passage 29, whose lower end communicates with the interior 30 of a crushing-chamber-providing member. The crushing chamber, in this illustrative embodiment, is supported by a series of supporting plate members 31 welded or otherwise suitably connected to the hollow shaft member 20, and the plate members 31 have welded to them spaced transverse, comparatively heavy support members 32 in the form of channel elements whose channels face toward the chamber space 30. The frame members 31 may be suitably lightened, as at 33, if desired.

The peripheral chamber walls, in the planes of oscillation of the chamber-providing member 25 about the axis of the hollow shaft 20, are formed of a built-up construction, and various means of providing chamber walls of adequate strength but with large areas for the escape outwardly of pulverized material, may be employed. Advantageously, as in this particular illustrative embodiment, these walls may be built up of a relatively large number of comparatively thin laminations between which, in any suitable manner, whether by providing actual separate spacer elements between the laminations, or by providing projections on the laminations themselves so as to provide adequate space between them, or by corrugating the laminations, or otherwise, there will be provided narrow passages whose total length between any pair of laminations will be very great, and will indeed probably exceed in most cases the total chamber length. In the specific form of built-up chamber construction shown in Figs. 1 to 10 inclusive, it will be noted that a series of laminations 35, each having outwardly extending ears 36 perforated as at 37, are spaced by thin spacer elements 38, and the entire series of laminations and spacer elements are "strung" upon holding bolts or tension rods 39, being at one side connected by these bolts to a side plate 40; and at the other side of the chamber, after the assemblage of laminations has been placed in position between the plate members 31, a second side plate 41 may be applied; and by placing nuts 42 upon the tension rods 39 the built-up chamber wall unit may be secured in

place. A removable cover 43 is provided in one side wall member of the rocker chamber, and the wall 3 is provided with a removable cover 44, which may be removed to permit access to and withdrawal of the laminated chamber wall assembly. It will be noted that the ears 36 enter the channels provided by the transverse channel support elements 32, and thereby provide a positively locked construction. It will be evident that instead of employing a construction in which the chamber is clamped in position by the use of plates engaging the most remotely spaced lateral members 31, a perfectly complete, rigidly connected unit built up of the laminae 35 may be employed and simply put in position by bodily inserting movement in one direction and then bolted in place to the more accessible support member 31.

The shaft 20 is provided at its end with a depending arm 46 which is provided with a plurality of sockets 47 for the reception of a wrist pin 48. This wrist pin is connected by a connecting rod or pitman 49 to the crank pin 50 of a crank disk 51 mounted upon the cross shaft 12, and the latter is driven herein through a suitable combined flywheel and drive pulley 52 supported on the shaft 12 outside the side wall 3. A removable cover plate 55 is provided in the wall 5 to permit access to the wrist pin, and a top cover member 56 provides total enclosure for the parts within the chamber 8. A removable cover 57 is provided to permit access to the interior of the cylindrical member 11 to enable examination and adjustment of the bearings.

It will be understood that through some suitable form of apparatus a flow of a fluid medium adapted to maintain in suspension and bear away ground material is maintained in the chamber 15. Since the purpose of this apparatus is to perform fine grinding operations, which means that the finished product may be called on to pass through 200 mesh screen, it will be evident that the spaces between the laminae may be very narrow as, for example, of the order of 0.003 inch.

It is important to note that the chamber 30 is of comparatively low dimension from top to bottom. It will be noted that the capacity of the chamber may be varied within reason by modifying its transverse dimension. Its rate of feed will be controlled, somewhat indirectly perhaps, by the dimension of the passage 29, for the grinding rate will depend on conditions within the chamber, and the feed is controlled automatically by the rate at which ground material leaves the chamber, and supply passage dimension is a factor in chamber fullness, which affects grinding rate in some degree. Due to the fact that the chamber, by reason of its rapid oscillation, will cause its charge of mingled material to be processed and reducing medium to act more or less as a piston within the chamber, it will be appreciated that choking of the chamber due to too rapid feed will not be possible, for during nearly all of the opposite oscillatory movements of the chamber, the chamber will be filled substantially from top to botom by the moving mass of its contents and only at the extreme positions of this moving mass will there be much room for ingress of material, this occurring at such times as the moving mass, due to concentration in one end or the other of the chamber, may leave a small area at one edge or the other of the passage 29 open. It will be evident that the device will be self-regulating in the matter of feed, therefore.

From what has been said, it will be evident that upon drive of the combined flywheel and driving pulley 52 by any suitable means, as, for example, by a motor driven belt 59, the crank pin 50 will cause the connecting rod 49 to move the wrist pin 48 and thereby oscillate the arm 46, and the latter, being connected to the hollow shaft 20, will rock the shaft. The chamber 25, being connected with the hollow shaft, will be oscillated through an angle which will be determined by the throw of the crank pin 50, the length of the arm 46, etc.; and since the chamber 30 will be provided with a substantial charge, as at 60, of pulverizing medium in the form of balls or other masses of hard grinding material, preferably in sizes ranging perhaps from half an inch to an inch, down to even as small as one thirty-second of an inch, it will be evident that the grinding medium will be thrown back and forth from end to end of the chamber as the grinding operation is carried on. It will be evident that the material which will be supplied through the chute 27, opening 26, the interior of the shaft 20, port 28, and passage 29, will mingle with the pulverizing medium; and since the density of a mass of particles of unequal size is a maximum where the particles are the smallest, the smaller balls or other pulverizing medium elements will seek the outer portions of the grinding chamber, and in like manner the more finely divided particles of material to be reduced in size will further inter-penetrate among the grinding particles and tend to seek the outer portions of the chamber. It will, therefore, be evident that there will be a segregation of grinding elements and of material according to size, with the larger particles of material to be reduced subjected to the action of the larger grinding elements, and the more finely divided material to be reduced in size acted upon by the material grinding medium of finer size. It will be obvious that a very large amount of discharge area is provided, and that from almost anywhere in the circumferential walls of the chamber a particle adequately reduced in size may escape by very short direct movement. It will be noted that due to the effects of centrifugal force there is a grinding action by attrition as the mass of material within the chamber travels back and forth along the lower wall of the chamber. It will be evident, moreover, that there is material reduction by impact as portions of the charge of pulverizing medium and material to be ground are subjected to the action of the end walls of the chamber; and, of course, as the directions of movement of the contained mass are reversed, there will be inter-action within the mass, so that an extremely effective grinding action will be attained. It will be observed that the chamber comprises concylindric walls (herein top and bottom walls) each of which provides discharge openings, and of which each lamination—so to speak—forms a part.

The matter of chamber dimension is subject to wide variation, as is also the quantity of pulverizing medium used. Obviously, depending upon the hardness of the material, impact will play a more or less important part in the entire process. Where maximum reliance on impact may be desired, the free travel of the charge of pulverizing material and material to be reduced in size will preferably be perhaps 1.5 times the stroke of the chamber, as the stroke is measured in the arcuate path of chamber movement. Very satisfactory results, however, are attainable with values of the ratio of free travel to stroke of 1.5 to 1.75, and when sharp impact is not of great moment, due

to the readily friable nature of the material to be ground, chamber dimension may be shortened, or, as by increase of size in inlet passage, relative contents increased, and very satisfactory results with a "play" to stroke ratio of less than 1.5 obtained. The quantity of grinding material may obviously be varied within wide ranges also, and because of the self-regulating characterisic the total quantity of material within the chamber will be, however, controlled, and the rate of grinding will be measured to some extent by the quantity of pulverizing medium employed. The construction shown and described is for dry grinding, but obviously, the apparatus, with a different discharge arrangement, and any other suitable or needed modifications and adjuncts, may be used for wet grinding.

While I have described above a construction in which the top, bottom and end walls are built up of laminae it will be evident that if lateral discharge be desired, the side and end walls, or the side walls alone, can be built up of laminae providing suitable discharge spaces. Also the top and bottom walls may be perforated, the side and/or end walls made of laminae, the parts suitably connected as by radial or chordal tension members, and a very large discharge area provided. If it is desired to build up the side and end walls together of laminae in the form of the outline of the chamber, the laminae may be curved if desired to conform to the radius or radii of curvature of the casing.

As illustrative of some of the other variations in construction mentioned and falling within the scope of my invention I have shown further modifield construction respectively in Figs. 11 to 15, inclusive, and in Figs. 16 to 19, inclusive.

In Figs. 11 to 15 the departure from the preferred embodiment described in detail above is less substantial than in Figs. 16 to 19, and the primary difference from the preferred embodiment resides in the use of wall elements which while the equivalents of laminae, lack the thin-plate characteristic commonly associated with laminae. As the difference is confined to the pulverizing chamber construction, I have not illustrated most of the features of construction which are identical in this and in the preferred embodiment. It may be noted that in the rocker receiving-chamber 15 provided by the pan 13 and cover member 16 there is pivoted a power-oscillated pulverizing-chamber-providing member 25' supported from a hollow shaft 20' and providing a chamber 30' containing a quantity of pulverizing elements 60'. The chamber-providing member 25' is supported by suitable more-or-less fan-shaped supporting plates 31' connected to each other by transverse bars 32', to which they are severally welded, as well as being welded to the shaft member 20'. Herein the right-hand plate 31' in Fig. 12 is not cut away opposite the chamber 30', but forms a solid side chamber wall. The other thin plates are, however, cut away internally to the general form or outline of the desired chamber contour and have the bars 32' welded to their inner surfaces. Into the framework thus provided I insert liner or wall-forming elements 61, each of suitable round or polygonal stock, and adapted to be sprung into position and then slid laterally into engagement with the next similar member. The lateral edges of the members 61 may be notched, grooved, knurled, or the like, as at 62 to provide for the outward passage of the pulverized material, and it will be evident that by unevenly spaced grooving, or unequally or oppositely angled grooving, closing of the passages upon lateral engagement of the members 61 may be prevented. It is also possible, with this type of construction to corrugate the members 61, thereby to provide passages for the escape of pulverized material.

When the full lateral width of the framework is filled with contacting members 61 a side plate 64 may be placed in position, and held by nuts 65 and threaded rods 66, the rods passing within the spaces 67 between the members 32' and being positioned by their mountings in the right-hand member 31' and in the plate 64.

It will be noted that this form of construction provides certain advantages not present in the form first described, though lacking others. Because of the broader elements, wider at their contact areas than at their surfaces engaged by the chamber contents, peening is rendered less rapid and detrimental, and very considerable wear may take place without any effect whatever upon the area of the escape passages for the pulverized material. The general mode of operation of the apparatus as a whole being closely similar to the embodiment of the invention disclosed in Figs. 1 to 10 inclusive, further detailed description is unnecessary.

Figs. 16 to 19 inclusive disclose an embodiment of the invention in which the discharge orifices are provided in the lateral chamber walls and in the end chamber walls, instead of in the top, end and bottom walls. Obviously the lateral walls and end walls may be built up separately (i. e. individually) of laminae, or rods, or the like, providing discharge orifices between them, and suitably held together by tie members, or by spot welding, or in other ways that will be evident, in the light of this present disclosure, to those skilled in the art. However, as illustrating another embodiment which my invention may assume in practice and incorporating the feature of wall elements each providing portions of a plurality of chamber walls, I show in Figs. 16 to 19 a built-up construction in which the two side walls and the two end walls are formed by superimposed units each of which forms a portion of each of the enumerated walls.

In this illustrative embodiment of the invention it will be noted that a chamber-providing structure, generally designated 25'' is supported for rocking movement or oscillation about the axis of a hollow shaft 20'', being supported from the latter by the four generally fan-shaped members 31'' welded to the shaft 20'' and having flange portions (so that they are T-shape in cross section at points adjacent the chamber proper) 72 welded to imperforate-concylindric bottom and top plate members respectively numbered 70 and 71. The flange portions 72 upon the radially extending portions 73 of the members 31'' provide abutment surfaces extending transversely to the planes of chamber oscillation of substantial surface area. Within the space bounded by the bottom plate 70, the top plate 71 and the flanges 72 of the portions 73 of the members 31'', I provide a series of superimposed wall forming elements 74, each generally rectangular in plan and curved about an axis coincident with the axis of oscillation of the shaft 20''. The elements 74 are cut away internally as at 75 to provide the limits of the chamber 30'' in which the grinding medium 60'' is enclosed. The individual laminae or plate-members 74 are struck up as at 76 to provide narrow slits 77 for the escape of pulverized material between the wall elements, the bosses so provided

being unevenly spaced, to prevent telescoping, and so complete surface contact between adjacent plate members. When the space above designated is filled from top to bottom by the stacked plate elements **74**, lateral clamping plates **78** and **79**, each in the form of a mere rim engaging the edges of a few top and bottom plates and the opposite ends of all the plates, are clamped in position by through bolts **80** and nuts **81**, said bolts arranged in bores **82** in transverse sleeves **83** integral with the top and bottom plate and flange assembly.

The chamber-providing member **25''** is actuated, fed, and enclosed similarly to the chamber-providing member **25**, but it will be observed that the discharge of pulverized material will occur through the slits **77** in the end walls and in the side walls of the chamber, instead of as in the other embodiments above described. As the general mode of operation of this particular embodiment of the invention will therefore be readily understood, further detailed description may be omitted. In this form, it will be noted that the lateral discharge slits, while less effective, in a manner, due to the lack of throwing of the pulverized material against the side walls with the same force as against the end walls, yet permit the advantage that less peening is likely to occur and full discharge effectiveness may be longer maintained than in some other arrangements.

It will be obvious that each of the embodiments of my invention described is highly effective, durable, not expensive to manufacture, and provides very large discharge orifice area, and among them they accomplish all the desirable objects set forth above. As compared with structures formed of solid plates, the orifice areas may be greatly increased without having to have individual orifices of undesirably large size in any dimension, and a very much cheaper construction, with much less chance of loss due to defective workmanship, is secured.

While I have in this application specifically described three forms which my invention may assume in practice, it will be understood that these forms of the same are shown for purposes of illustration, and that the invention may be 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. For a mill of the character in which a generally arcuate grinding chamber is supported for oscillatory movement and has such movement positively imparted thereto, a grinding chamber having an inlet in the top thereof for material to be ground and having wall elements cooperating to form a generally arcuate grinding space having concentric, equally spaced, top and bottom walls and wholly enclosed except for said inlet and for discharge orifices and of substantially uniform cross section normal to its path of oscillation throughout the major portion of its length, said elements providing between them orifices for the discharge of ground material through the top, ends and bottom of the chamber and having associated means for holding them in fixed relation to each other when assembled.

2. For a mill of the character in which a generally arcuate grinding chamber is supported for oscillatory movement and has such movement positively imparted thereto, a grinding chamber having an inlet in the top thereof for material to be ground and having wall elements cooperating to form a generally arcuate grinding space having concentric, equally spaced, top and bottom walls and wholly enclosed except for said inlet and for discharge orifices and of substantially uniform cross section normal to its path of oscillation throughout the major portion of its length, said elements providing between them orifices for the discharge of ground material through the top and bottom of the chamber and having associated means for holding them in fixed relation to each other when assembled.

3. For a mill of the character in which a generally arcuate grinding chamber is supported for oscillatory movement and has such movement positively imparted thereto, a grinding chamber having an inlet in the top thereof for material to be ground and having wall elements cooperating to form a generally arcuate grinding space having concentric, equally spaced, top and bottom walls and wholly enclosed except for said inlet and for discharge orifices and of substantially uniform cross section normal to its path of oscillation throughout the major portion of its length, said elements providing between them orifices for the discharge of ground material through the top and ends of the chamber and having associated means for holding them in fixed relation to each other when assembled.

4. For a mill of the character in which a generally arcuate grinding chamber is supported for oscillatory movement and has such movement positively imparted thereto, a grinding chamber having an inlet in the top thereof for material to be ground and having wall elements cooperating to form a generally arcuate grinding space having concentric, equally spaced, top and bottom walls and wholly enclosed except for said inlet and for discharge orifices and of substantially uniform cross section normal to its path of oscillation throughout the major portion of its length, said elements providing between them orifices for the discharge of ground material through the bottom and ends of the chamber and having associated means for holding them in fixed relation to each other when assembled.

5. For a mill of the character in which a generally arcuate grinding chamber is supported for oscillatory movement and has such movement positively imparted thereto, a grinding chamber having an inlet in the top thereof for material to be ground and having wall elements cooperating to form a generally arcuate grinding space having concentric, equally spaced, top and bottom walls and wholly enclosed except for said inlet and for discharge orifices and of substantially uniform cross section normal to its path of oscillation throughout the major portion of its length, said elements providing between them orifices for the discharge of ground material through the sides of the chamber and having associated means for holding them in fixed relation to each other when assembled.

6. For a mill of the character in which a generally arcuate grinding chamber is supported for oscillatory movement and has such movement positively imparted thereto, a grinding chamber having an inlet in the top thereof for material to be ground and having wall elements cooperating to form a generally arcuate grinding space having concentric, equally spaced, top and bottom walls and wholly enclosed except for said inlet and for discharge orifices and of substantially uniform cross section normal to its path of oscillation throughout the major portion of its length, said elements providing between them ori-

fices for the discharge of ground material through the sides and ends of the chamber and having associated means for holding them in fixed relation to each other when assembled.

7. As a wall element for a pulverizing chamber having an opening through its top for the introduction of material thereinto, a strip having spaced rebent ends and adapted to form an element of the bottom, ends and top of the chamber and with a contiguous strip to provide a discharge orifice, said rebent ends spaced from each other to leave room for said feed opening and adapted to form respectively portions of the opposite ends of the top wall of the chamber.

8. As a wall element for a pulverizing chamber having an opening through its top for the introduction of material thereinto, a strip having spaced rebent ends and adapted to form an element of the bottom, ends and top of the chamber, said rebent ends spaced from each other to leave room for said feed opening, adapted to form respectively portions of the opposite ends of the top wall of the chamber, and each including a portion substantially uniformly spaced from the portion along which it is rebent.

9. As a wall element for a pulverizing chamber, a strip bent on an arc and having its ends rebent to provide arcuate portions of substantial length extending towards each other and struck from the same center as said arc but on a shorter radius.

10. In a mill, an elongated size-reducing chamber reciprocated in its direction of elongation and having side walls and other walls cooperating with said side walls to bound said chamber, said chamber having a material supply opening in one of said other walls and having substantially the entire wall area thereof except said sides formed by narrow contiguous elements each extending from one boundary of said opening around the chamber to the opposite boundary of said opening, said elements rigidly connected together and providing between them discharge apertures for size-reduced material.

11. For a mill of the character in which a generally arcuate grinding chamber is supported for oscillatory movement and has such movement positively imparted thereto, a grinding chamber providing a grinding space generally arcuate in planes perpendicular to the axis of oscillation of the chamber and having inner and outer arcuate walls each at the same side of and both spaced, but unequally, from said axis, and said chamber of substantially uniform cross section normal to its path of oscillation throughout the major portion of its length and having a wall built up of laminations providing between them spaces for the discharge of ground material.

12. In a mill, an arcuate oscillatably supported chamber having concylindric walls struck on different radii from a common axis and both arranged, to provide a chamber of uniform cross section on radial planes, at the same side of the axis of oscillation and formed by elements each of narrow width and each of which comprises a portion providing a part of both of said walls.

13. In a pulverizing mill a support mounted for oscillatory movement and having such movement positively imparted thereto and providing a feed passage and a frame-work with respect to which said feed passage is substantially central for the reception of a grinding chamber to be moved thereby, and a built-up laminated structure insertible and removable as a whole relative to said frame-work and rigidly positionable in the latter, and providing the top, end and bottom walls for a chamber.

14. As a wall element for a pulverizing chamber, a strip having a portion concave in side elevation, and separated spaced portions extending towards each other and connected at their relatively remote ends to the opposite ends of said first-mentioned portion and so spaced relative to the latter that the distances between said second-mentioned portions and said first-mentioned portion along normals to said first-mentioned portion are substantially uniform substantially throughout the lengths of said second-mentioned portions.

15. As a wall element for a pulverizing chamber, a strip bent on an arc and having its ends rebent to provide arcuate portions of substantial length extending towards each other and struck from the same center as said arc but on a shorter radius, said strip having radial indentations in its lateral surfaces.

16. As a wall element for a pulverizing chamber, a strip bent on an arc and having its ends rebent to provide arcuate portions of substantial length extending towards each other and struck from the same center as said arc but on a shorter radius, said strip having spaced lateral protuberances on at least one side thereof to space it from a contiguous strip.

17. For a mill of the character in which a generally arcuate grinding chamber is supported for oscillatory movement and has such movement positively imparted thereto, a grinding chamber providing a grinding space generally arcuate in planes perpendicular to the axis of oscillation of the chamber and having inner and outer arcuate walls each at the same side of and both spaced, but unequally, from said axis, and said chamber of substantially uniform cross section normal to its path of oscillation throughout the major portion of its length and having a wall built up of a multiplicity of elements providing between them a series of generally parallel slots for the discharge of ground material.

ROBERT S. BUTLER.