Jan. 15, 1952 C. A. ADAMS 2,582,734

HORIZONTAL GYRATORY ROLL CRUSHER

Filed June 27, 1946 2 SHEETS—SHEET 1

FIG. 1.

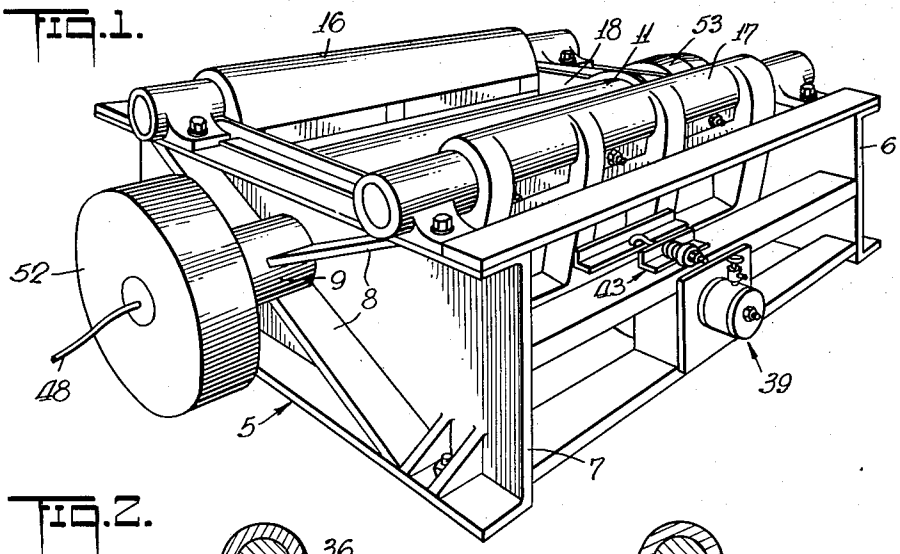


FIG. 2.

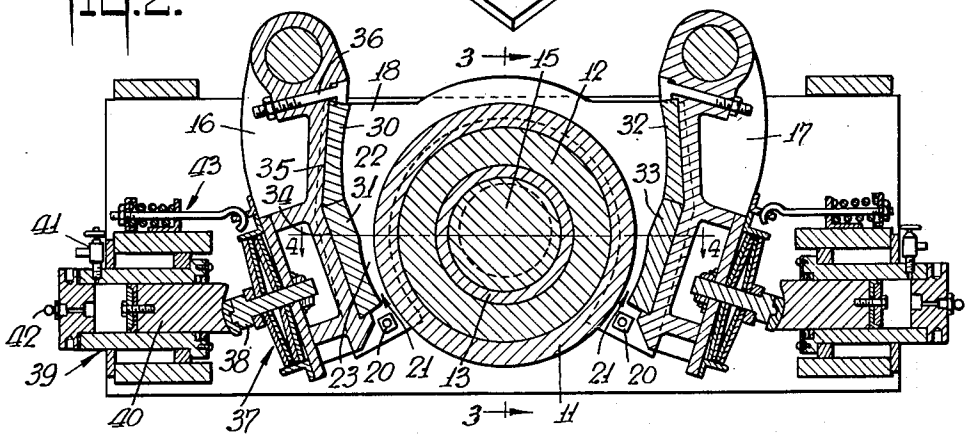
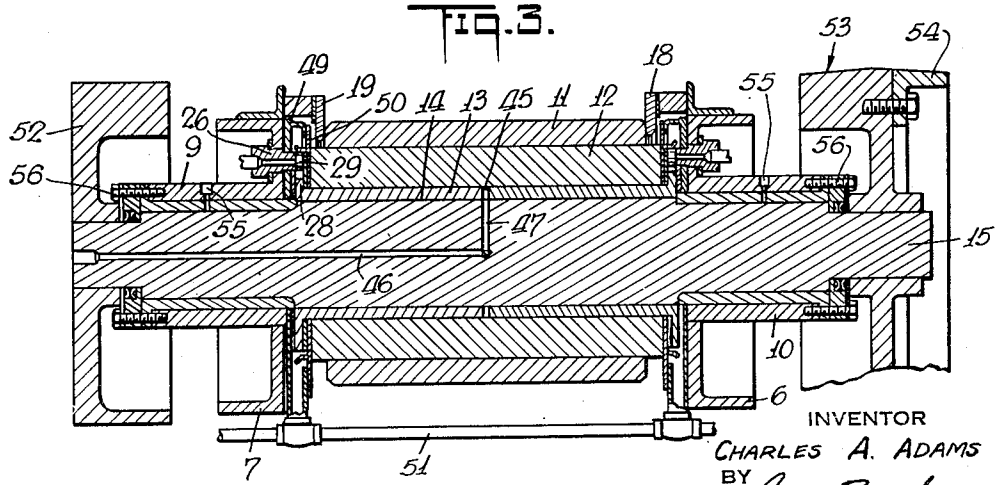


FIG. 3.



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FIG. 4.

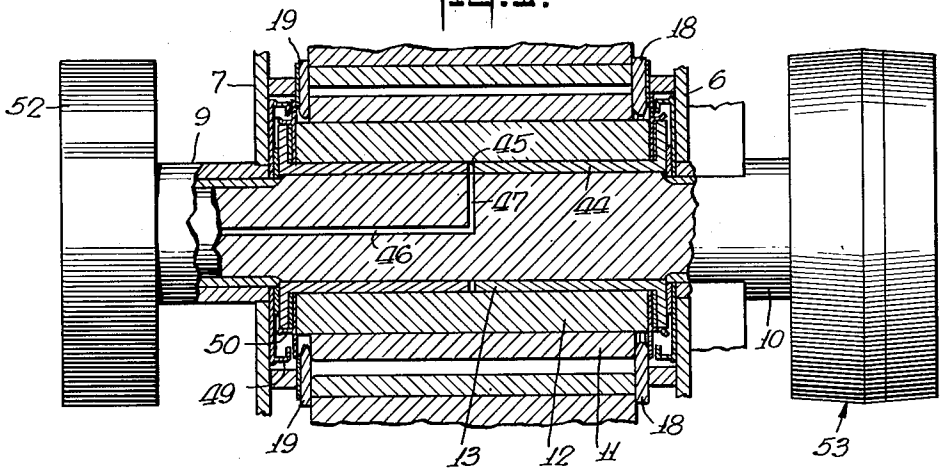


FIG. 6.

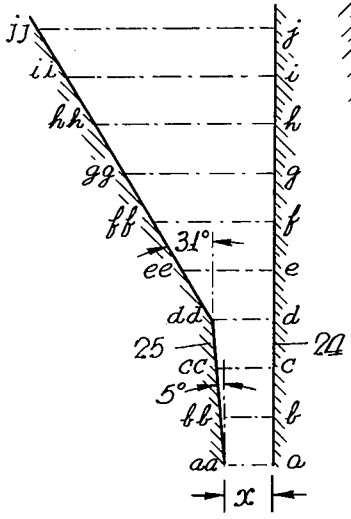


FIG. 7.

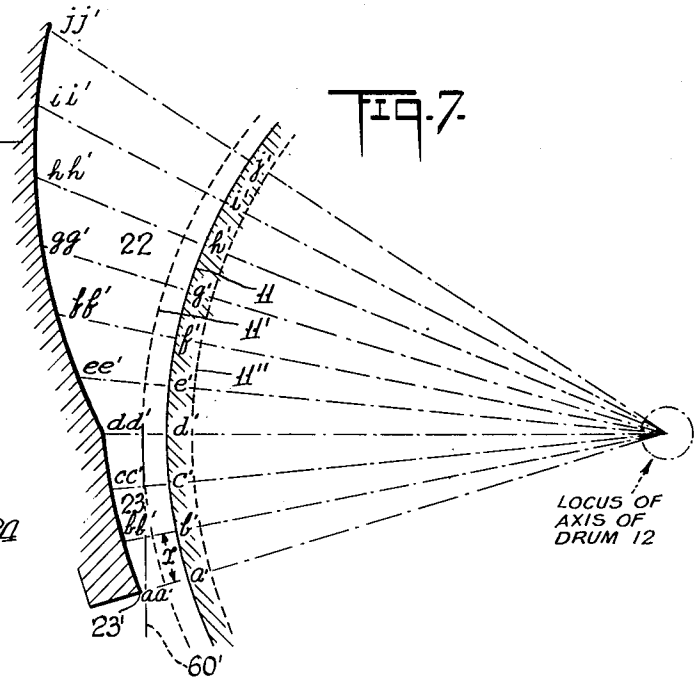
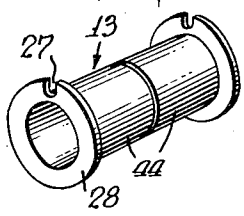


FIG. 5.



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Patented Jan. 15, 1952

2,582,734

UNITED STATES PATENT OFFICE

2,582,734

HORIZONTAL GYRATORY ROLL CRUSHER

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Application June 27, 1946, Serial No. 679,665

8 Claims. (Cl. 241—142)

1.

My invention relates to crushers and in particular to gyrocentric machines for crushing rocks, ores, slag, and other crystalline materials.

In so-called horizontal gyrating rock-crushing machinery, it has been customary to feed the material to be crushed into a somewhat funnel-shaped passage between a relatively fixed crushing jaw and a gyrating or eccentrically moving crusher drum. The funnel-shaped passage has been defined by the gradual convergence of the generally cylindrical periphery of the crusher drum and of the arcuate surface of the crushing-jaw plate. Power requirements for operating devices of this construction have been great, principally because of the phenomenon known as choking. This phenomenon takes place at points of close adjacency of the drum and the jaw plate, due to an inability of finely crushed elements to free themselves so as to permit the admission of further charges of partially crushed material. The choking phenomenon has caused undue wear of parts and frequent breakage.

It is, accordingly, an object of my invention to provide a crushing machine having improved features of economy of operation.

It is also an object to provide a crushing device in which the power supplied is utilized substantially only for crushing purposes.

It is a further object to provide a drum-type crushing device in which, for the life of the drum, wear of the crushing surfaces is more evenly distributed.

It is a more specific object to provide a drum-type crusher in which motion of the crusher drum is substantially only eccentric in nature and in which the amount of rotational motion of said drum is a more direct reflection of the magnitude of the crushing load sustained.

Other objects and various further features of novelty and invention will appear from a reading of the following specification in conjunction with the accompanying drawings, in which:

Fig. 1 is a perspective view of a crushing machine incorporating features of the invention;

Fig. 2 is a cross-sectional view of the crusher of Fig. 1, taken transversely and at substantially the midpoint of the drive shaft;

Fig. 3 is a cross-sectional view taken substantially in the plane 3—3 of Fig. 2;

Fig. 4 is a fragmentary cross-sectional view taken substantially in the horizontal plane including the main rotational axis of Fig. 1, as taken in the plane 4—4 of Fig. 2;

Fig. 5 is an isometric view of parts of the device shown in the foregoing figures; and

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Figs. 6 and 7 are constructional diagrams illustrating a method of developing crushing surfaces in accordance with the invention.

Broadly speaking, my invention seeks to provide improved operating efficiency in a gravity-fed machine in which crushing action is effected by two funnelling members moving relatively to each other. The improved efficiency results from employment of crushing surfaces making a relatively wide included angle (approximately the angle of nip for the material to be crushed) with each other, except in the region of finest crushing action, where the included angle is substantially less than the angle of nip. In the region of coarse crushing, the included angle is preferably such as to produce a crush with an upward breaking thrust, while in the fine-crush zone the relatively narrow included angle is preferably as wide as possible without producing substantial upward breaking thrust. In the specific form to be described, the crusher is a horizontal roll or drum, eccentrically gyrated between adjustable jaw plates, whereby crushing may be effected alternately on opposite sides of said drum in an up-crushing zone and in a down-crushing zone. Each jaw plate has a complex crushing surface characterized by two generally arcuate elements which define a fine-crush region and a coarse-crush region. The relative size of the fine-crush surface with respect to crusher-drum diameter and with respect to the effective area of the coarse-crush surface is preferably such that with the roll retraction following each crushing stroke the finely crushed material may be completely discharged, thus preventing attainment of choking conditions in the fine-crush region.

Referring to the drawings, my invention is shown in application to a horizontal gyrating roll crusher having a frame 5 including side frame members 6 and 7. These members are reinforced as at 8 to provide rugged outboard bearings 9—10 for the main eccentrically gyrated crusher drum. In the form shown, the crusher drum comprises a mantle or crushing portion 11 carried on an annular drum or support member 12. The drum 12 is in turn supported as by sleeve means 13 on eccentric means in the form of a cylindrical surface 14 of the main drive shaft 15; the axis of the cylindrical surface 14 is displaced from the axis of the shaft 15 so as to impart an eccentrical throw to the crushing mantle 11 for crushing purposes.

The crushing action occurs between the eccentrically gyrated crushing drum and the crushing-plate surfaces of a pair of swing jaws 16—17

pivotally mounted on the frame members 6 and 7 to either side of the drum 12. Side plates 18 and 19 are mounted as by bolts 20 to the frame members 6 and 7 to form a close but free fit with the ends of the crushing jaws and of the crushing-drum mantle 11, thereby defining the crushing chamber. In practice, rock or other material to be crushed is introduced from above into this chamber where, with each gyration of the mantle 11, another increment of material is finely crushed and discharged by gravity through the relatively narrow passages 21 characterizing the crushing-chamber exit. The elements thus far described are of a conventional nature and are therefore well known.

According to the invention the efficiency of crushing action is improved by novel construction of the walls of the crushing chamber. In the form shown, this novel construction is applied to the crushing jaws 16 and 17 to produce a double arcing of their crushing surfaces. As indicated above, this double arcing is for the purpose of separately defining within the crushing chamber a coarse-crush region 22 and a fine-crush region 23, the contents of the latter being substantially completely discharged for each retracting throw of the crushing mantle 11. The coarse-crush region is preferably defined by two outwardly divergent surfaces for which the included angle is substantially the angle of nip for the material to be crushed; in the fine-crush region this included angle of divergence is materially less.

Due to the necessarily arcuate surface of the mantle 11, the diverging walls of the crushing chamber in both the fine and coarse-crush regions 23 and 22 are also arcuate; nevertheless, it is preferred that the included angles be maintained as indicated. To illustrate a method of developing suitable arcuate surfaces for the crushing jaws a simplified case is laid out in Figs. 6 and 7. According to this method, the above-stated desired included-angle relationships are first constructed for plane surfaces (Fig. 6) and the element-to-element spacial relationships are then transposed (Fig. 7) to the curved surfaces which obtain for the machine under consideration.

For the case illustrated in Fig. 6, it is assumed that suitable fineness of product may be obtained by spacing the crushing members 24 and 25 by an element of length x, and that the region of fine crushing is defined by an included angle of 5°, the region extending a length $3x$. Further up, the coarse-crushing region is defined by an included angle of 31°, the assumed angle of nip for the material to be crushed (for most ores, stone, gravel, etc., the angle of nip is generally conceded to be 31° or less); in the form shown, the coarse-crushing region extends beyond the fine-crushing region a length approximately $6x$. To simplify the process of transposing the developed data of Fig. 6 to the arcuate case of Fig. 7, construction lines may be drawn normal to the plane surface of crushing element 24 for successive increments of x along the surface; the intercepts of these construction lines with the 5° and with the 31° inclined surfaces define the construction spans to be utilized in Fig. 7. These spans are identified as a—aa, b—bb, c—cc, etc.

Referring to Fig. 7, the coarse-crush region 22 and the fine-crush region 23 will be recognized between the generally cylindrical surface of the crushing mantle and the complex surface of the jaw 16. Dotted lines 11′ and 11″ indicate the extreme lateral positions for eccentric throw of the crushing surface of the mantle 11. To develop the complex surface of jaw 16, an average position of the crushing mantle 11 (full line, backed by cross-hatching) is laid out for the crushing mantle surface, and radially extending construction lines are drawn for each increment of x along the periphery. The construction points defined by these increments are identified by the legends a', b', c', etc. The complex surface is then developed by laying out for each of the points a', b', etc., spans a'—aa', b'—bb', etc. (taken directly from spans a—aa, b—bb, etc. of Fig. 6) along the radially extending construction lines passing through these points, as will be clear. To promote the rapid discharge of fine-crush material from the lower zone 23, I prefer that, whatever the placement of the jaw with respect to the mantle, the lower jaw lip 23′ (defining the lower limit of the fine-crush zone 23) shall be spaced from, or shall at least not substantially project (toward the drum axis) beyond an imaginary vertical plane 60 representing a vertical tangent to the crusher mantle at the time (see dotted line 11′) of nearest approach to the jaw.

It will be seen that with the two-arc construction which I have described, crushing is accomplished substantially in two stages. The first or coarse crushing zone is characterized by relatively wide divergence of the chamber walls, so that material crushed in this relatively wide region will break with an upward thrust (due to having provided a relatively large included angle dependent on the properties of the material to be crushed, so as to permit upward slippage of large particles). At the same time, smaller particles mixed with the larger sizes in this upper region will be agitated by the gyrating roll and, instead of being crushed in a mass together, will slip downward. This slippage and agitation tends to classify the materials as to size, allowing the finer particles to sift down to the lower or fine-crushing zone, where each charge to be crushed fine may be reduced with a single stroke which crushes substantially the entire mass in this lower region. It is believed that single-stroke crushing in the lower region 23 may result from the low slippage inherent for a chamber having the relatively slight included angle which characterizes this region. The action of the described two-stage crushing will thus be understood to relieve packing and choking of material and to promote "free-crushing," with a resultant more uniform finished product obtained at an expenditure of less power.

Although the change in crushing angles from the upper zone 22 to the lower zone 23 is shown to be, and has been implied as being, quite abrupt at the intersection at the two substantially arcuate surfaces, it is clear that this transitional line may be rounded slightly in manufacture or that it may be left to wear round in the course of use.

According to another feature of the invention, the sleeve means 13, which serves as a bearing support for the crushing drum 12 on the eccentric surface 14, also serves as a partial anchor to remove substantially all the purely rotational components of motion of the eccentric shaft 15. Thus, the motion of the crushing mantle 11 will be substantially only eccentric, and the mantle 11 may be said to be driven or supported by non-rotating eccentric means. Under heavy load conditions, however, and since the drum 12 is rotatable relative to the eccentric means, the increased localized friction between the drum 12 and sleeve means 13 will be understood to be such

as to promote and to permit slight progressive rotation of the mantle 11. Under the more adverse load conditions, this slight rotation will be understood to provide a means of automatically evenly distributing wear over the entire exposed surface of the mantle 11.

In the form shown, the sleeve means 13 is effectively anchored against rotation by the action of an axially extending stop 26 carried by a frame member 7 and extending into a radially extending slot 27 in a flange 28 in the sleeve means 13 (see Figs. 3 and 5). If desired, a free-wheeling roller 29 may be carried at the slot-engaging end of the stop 26, to reduce friction and wear in the walls of the slot 27. It will be understood that the depth of the slot 27 should be sufficient to accommodate the full eccentric throw of the surface 14 without impeding such throw.

To reduce maintenance costs, I provide a plurality of removable crusher-plate elements on each of the swing jaws 16 and 17. In the form shown, each crusher plate is made up of two plate elements (30, 31 for jaw 16, and 32, 33 for jaw 17) set obtusely in two correspondingly obtusely inclined plate-receiving recesses 34, 35 (of jaw 16). Preferably, the lower edge of the lower recess 34 is acutely inclined with respect to recess 34, so that a single wedging action applied at the top edge of upper plate 30 may serve to secure both plates 30 and 31 to the jaw-plate holder 16. This wedging action is shown to be supplied by adjustable take-up of bolt means 36 having a wedge-shaped head mating with the acutely-inclined upper edge of plate 30 and with the obtusely inclined upper edge of the recess 33. It will be clear that the structure described for the crusher-plate assembly constitutes not only an improvement over previous methods of mounting but also a means for readily interchanging parts, particularly those representing areas subjected to greater wear.

In order to relieve stresses due to abnormally high crushing efforts demanded by certain undesired contaminations of the material to be crushed or by other unanticipated load conditions, I provide novel resilient shock-absorbing means linking the swing jaws 16 and 17 to the frame of the machine. For opposing the frequently occurring and relatively small load transients, I employ, in the form shown, a short-displacement resilient mechanism including oppositely dished frusto-conical washers 37. The butt end 38 of the stud resiliently carried by springs 37 is preferably formed with a generally spherical convex surface, for a purpose which will be clear. To oppose the less frequently occurring and abnormally large transient forces, I employ a hydraulic absorber 39 securely mounted to the frame of the machine and having a piston 40. In the form shown, piston 40 is formed with a generally spherical concave end to receive the butt end 38 resiliently supporting the jaw 16. Safety-valve means 41 serve to relieve excessive pressures within the absorber 39, and a standard fitting 42 may be employed for replenishing the supply of hydraulic absorber fluid. A relatively weakly sprung link 43 may be used to avoid "chatter" or transient separation of piston 40 from the butt 38.

It is clear that, aside from the function of protecting the crushing jaws, the frame, and the eccentric mechanism against excessive mechanical overload, the hydraulic absorbers may, depending upon the volume of fluid employed, serve

the additional function of accurately positioning the swing jaws in accordance with the relative wear of crushing surfaces and in accordance with the desired fineness of crushed product. If permanent connection is made via the fitting 42 to a source of adjustable fluid pressure, the desired positions of crushing surfaces may be automatically maintained by simple adjustment of the fluid pressure, as will be understood. The generally spherical mating surfaces of butt 38 and of piston 40 may then serve to translate absorbent forces from absorber 39 to the swing jaw 16 for a number of possible positions of the swing jaw 16.

In accordance with a further feature of the invention the sleeve means 13 is formed in two similar parts each of which is characterized by a generally annular bearing portion 44 and by a side flange 28. The axial length of the bearing portions 44 is preferably such that when the flanges 28 are in abutment with the ends of crushing drum 12 the inner ends of the bearing portions 44 are slightly spaced, to provide an annular manifold 45 for the peripherally uniform conduct of lubricating fluid to the interfitting bearing surfaces of the eccentric cylinder 14 of the sleeve means 13 and of the drum 12. In the form shown, the supply of lubricant to the manifold 45 is effected by a drilled duct extending first axially, as at 46, and then radially, as at 47 into communication with the manifold 45. If desired, this lubrication may be effected continuously under pressure through a suitable feeding mechanism 48 terminating at one end of the shaft 15.

The lubrication process for the eccentrically thrown components is completed by means of an extraction system at both ends of the crusher drum for removing dust-laden or otherwise-contaminated lubricant. In the form shown, closely overlapping members 49—50 are supported respectively on the frame member 7 and on the drum 12 to define an annularly extending exhaust manifold for receiving used lubricant exuding from the main-bearing surfaces and from the eccentric-bearing surfaces of sleeve means 13. An exhaust line 51, which is preferably maintained at reduced pressure, communicates with the exhaust manifolds at both ends of the machine for collection of used lubricant for possible filtration and recirculation under high pressure.

In accordance with a still further feature of the invention, smooth operation of my machine is promoted by a balancing of the eccentrically gyrated mass with suitable counterweights or fly wheels 52—53 carried by the shaft at both sides of the machine external to the outboard bearings 9—10. In the form shown, both counterweights resemble eccentrically loaded pulleys and one of these counterweights (53) is slightly enlarged by means of a flange 54 to accommodate a drive belt (not shown).

It will be clear that I have described a crushing machine having improved features of economy of operation. Not only do the novel crushing-chamber surfaces make possible greater and better quality output for less power, but the fact that my construction represents less compromising of crushing requirements than does a conventional single-arc crusher means that the same volume of crushing load may be handled in a machine needing less head-room clearance. Wear of crushing surfaces may be more evenly distributed (1) by the automatic relatively slow rotation of mantle 11 in accordance with the load,

and (2) by simple interchanging or servicing of the jaw-plate areas most subjected to wear. The spring-and-hydraulic shock-absorbing mechanism relieves the cooperating parts of undue stresses, with a resultant prolonging of mechanical service.

I have indicated how my novel shock-absorbing mechanism may, with suitable adjustment of hydraulic pressure in the cylinders 39, serve alternatively to take-up the mean positioning of the jaws 16 and 17 with wear of their crushing surfaces or to position the jaws for a given fineness of crush. Further adjustments of the crushing surfaces for either of these purposes may be effected by suitable bearings for the pivot journals carrying the jaws 16—17. It will be understood that such adjustment may readily be made by bolting these pivot bearings through slotted ways (not shown) in the upper flanges of the side frame members 6—7.

It will also be clear that the lubrication system described for the eccentrically thrown components may be utilized in part for efficient lubrication of the main outboard bearings 9—10. In the form shown, each of these bearings includes a feed duct 55 for clean lubricant and lubricant-sealing means 56 at the outer exposed end of the bearing. The inner ends of the bearings are then open to the annular exhaust manifold defined by the overlapping members 49—50. With this construction, the bearings may be fed with clean lubricant from the same high-pressure system and drained of dirty used lubricant by the same exhaust system as has been described for the eccentrically thrown mechanism.

Although I have described my invention with particular reference to the preferred form shown, it will be understood that modifications may be made within the scope of the claims which follow.

I claim:

1. In a crushing device, a generally cylindrical crusher drum, cylindrical means including an outer cylindrical surface wholly supporting said drum and over which said drum is rotatable, rotating eccentric means for imparting eccentric motion to the axis of said cylindrical means, means holding said cylindrical means against rotation, the axis of rotation of said eccentric means being substantially horizontally disposed, jaw means having a crushing side for cooperation with said drum, said crushing side having two generally concave surfaces intersecting in substantially the same horizontal plane as the axis of rotation of said eccentric means, the upper of said surfaces making a larger included angle with the periphery of said drum than the lower of said surfaces, whereby the upper of said surfaces may cooperate with said drum to define a coarse-crush zone and the lower of said surfaces may cooperate with said drum to define a fine-crush zone.

2. In a crushing device, a frame, rotating eccentric means rotatable about an axis supported by said frame, said eccentric means including a generally cylindrical drum-supporting means, a crusher drum supported wholly on said drum-supporting means, and rotation-resisting means cooperating between said frame and said drum-supporting means for resisting rotational motion of said drum, said last-defined means including an axially projecting stop member carried by said frame and engageable in a radially extending slot at one end of said eccentric means.

3. In a crushing device, a generally continuously peripherally cylindrical crusher drum, cylindrical means including an outer cylindrical surface wholly supporting said drum on a horizontal axis, said drum being free to rotate on said cylindrical supporting means, rotating eccentric means for imparting eccentric motion to the axis of said cylindrical means, whereby a substantially vertical plane may be defined tangent to the outer surface of said drum at the location of maximum eccentric throw of said drum to one side thereof, means holding said cylindrical means against rotation, and relatively fixed jaw means supported in horizontally spaced relation with said one side of said drum and having a crushing side for cooperation with said drum, said crushing side having an upper generally concave surface making with the periphery of said drum a substantially constant first downwardly converging included angle, said crushing side also having a lower generally concave surface making with the periphery of said drum a substantially constant second downwardly converging included angle, whereby each of said concave surfaces may define with said drum essentially separate downwardly converging crushing zones, for the purpose described, the upper of said zones having a substantially larger effective included angle than the lower of said zones, the lower edge of said lower concave surface being for the most part spaced from and extending at most insubstantially through said plane.

4. In a crushing machine of the character indicated, a frame, a generally horizontally disposed cylindrical crusher drum, drum-supporting means, rotating eccentric means journalled in said frame for eccentrically gyrating said drum-supporting means, said drum being rotatably mounted relatively to said drum-supporting means, rotation-resisting means between said drum-supporting means and said frame to resist rotation of said drum-supporting means with gyration of said eccentric means, opposed generally upstanding longitudinally extending jaw means on opposite sides of said drum, whereby crushing may be effected alternately on opposite sides of said drum in an up-crushing zone and in a down-crushing zone, said jaw means on the side of the up-crushing zone comprising two adjacent concave crushing surfaces making with the periphery of said drum two different substantially constant downwardly converging effective included angles having the same direction of convergence, the surface characterized by the larger of said included angles being above the surface with the smaller of said included angles, and said larger included angle having a maximum extent of 32°, for the purpose described.

5. In a crushing device, a generally cylindrical crusher drum, rotating eccentric means for imparting eccentric motion to the axis of said drum, sleeve means intermediate said eccentric means and said drum, said drum being supported wholly by said sleeve means, and means holding said sleeve means against rotation, whereby said sleeve means may arrest the translation of purely rotational motion from said eccentric means to said drum, and further whereby said drum may creep around said sleeve as necessitated by wear and crushing load, for the purpose described.

6. In a crushing device, a frame, rotating eccentric means rotatable on an axis supported by said frame, said eccentric means including

an eccentrically thrown generally cylindrical surface, sleeve means extending substantially over said surface, a crusher drum carried by said sleeve means, jaw means on one side of said drum and defining with said drum a crushing chamber, and rotation-resisting means carried by said frame for arresting rotational motion of said sleeve, whereby substantially only eccentric motion is imparted to said drum, and further whereby rotational motion of said drum is proportional to the crushing load encountered by said drum in the crushing chamber.

7. In a crushing device, a frame, rotating eccentric means rotatable about an axis supported by said frame, said eccentric means including a generally cylindrical drum-supporting means, a crusher drum supported wholly on said drum-supporting means, and rotation-resisting means cooperating between said frame and said drum-supporting means for resisting rotational motion of said drum, for the purpose described.

8. In a crushing machine, a frame, a crusher drum, rotating eccentric means for imparting eccentric motion to said drum, sleeve means intermediate said eccentric means and said drum, said drum being wholly supported by said sleeve means, said sleeve means having a radially extending flange with a radially extending slot at one end of said drum, and means carried by said frame and engaging said slot for locking said sleeve means against rotation.

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