March 18, 1930. W. K. LIGGETT 1,751,009

PULVERIZING MACHINE

Original Filed May 20, 1918 2 Sheets-Sheet 1

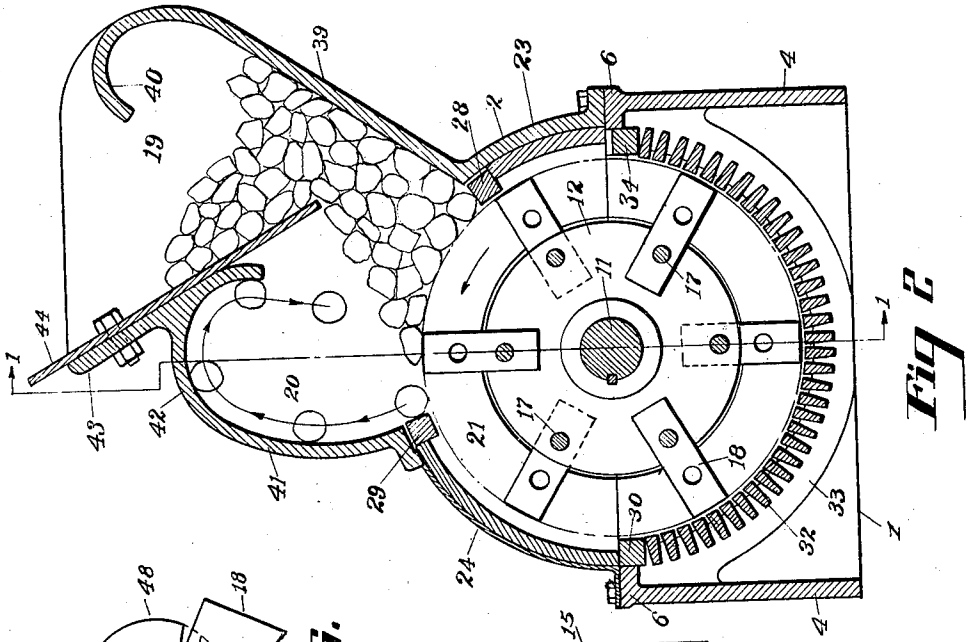


Fig 2

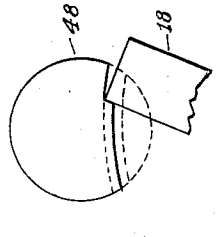


Fig. 5.



Fig. 1.

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PULVERIZING MACHINE

Original Filed May 20, 1918 2 Sheets-Sheet 2

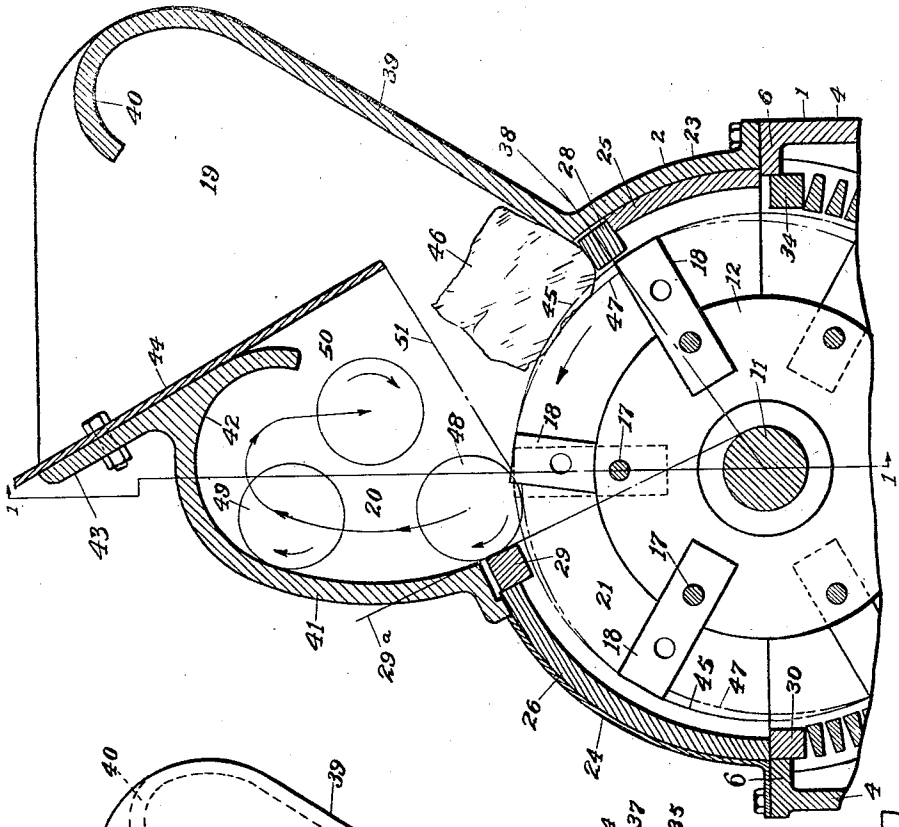


Fig. 4.

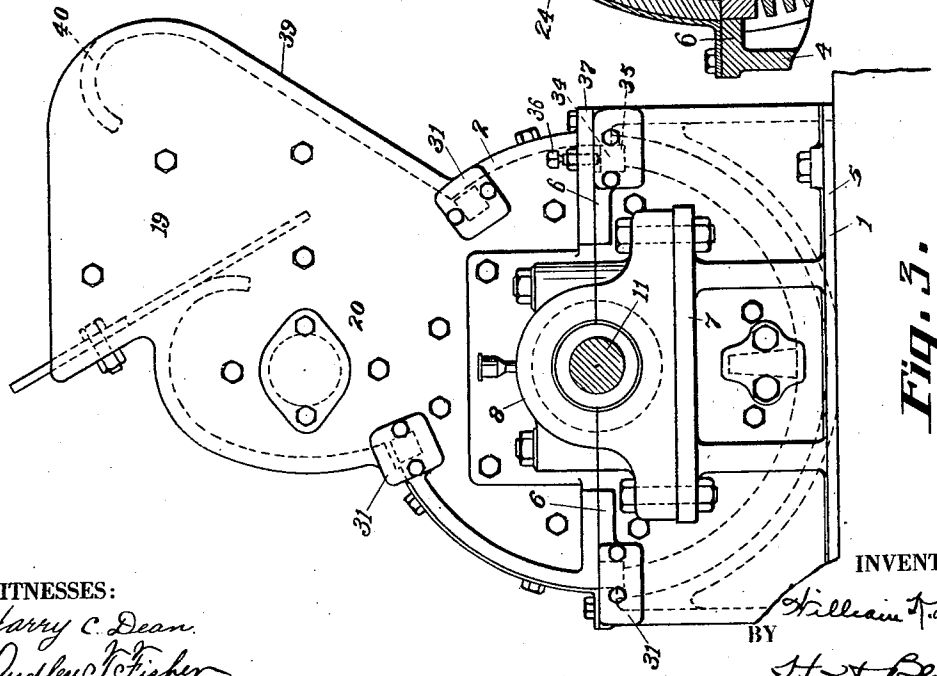


Fig. 3.

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Patented Mar. 18, 1930 1,751,009

# UNITED STATES PATENT OFFICE

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## PULVERIZING MACHINE

Application filed May 20, 1918, Serial No. 235,635. Renewed July 30, 1929.

The present invention relates to certain new and useful improvements in pulverizing machines, and particularly to that class of pulverizing machines in which each has an element adapted to revolve at high velocity and provided with reducing elements, shown, in the present example, as a plurality of pivotally mounted radially extending arms adapted to engage and pulverize material and a hopper having feeding and confining chambers arranged to receive and feed the material to be pulverized and retain or confine it within and return it to the influence or zone of action of the rapidly revolving arms until it shall be reduced to the desired degree of fineness.

The especial object of this invention is to provide an improved pulverizing machine which shall be adaptable to a wider range of use and which will operate with greater efficiency and uniformity of action than the machines heretofore manufactured.

The means whereby I attain this object are fully set forth in the following specification and illustrated in the accompanying drawings of which

Fig. 1 is a sectional view of the preferred embodiment of my invention taken along the line 1—1 of Fig. 2.

Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1.

Fig. 3 is an elevation of the machine illustrated in Figs. 1 and 2.

Figs. 4 and 5 are diagrammatic figures illustrating the action of the operative parts of the machine upon the material being pulverized.

Like numerals refer to similar parts in the several figures.

As illustrated in the drawing my improved pulverizing machine consists of a pulverizing element adapted to revolve at high velocity about a horizontal axis, mounted within a casing formed of a main supporting frame 1 and a housing 2 which are joined together along the horizontal central plane of the rotor. The main frame 1 consists of end walls 3 and side walls 4, formed of a single casting, provided along their lower edges with flanges 5 adapted to rest upon and be attached to any suitable foundation, and along their upper edges with flanges 6 to which the housing 2 may be bolted. Upon the end walls 3 are formed outwardly extending flanges, or shelves, 7 to which are bolted the bearing housing 8. Within the bearing housing 8 are mounted suitable ball bearings 9 on which the rotary element of the machine is supported. The inner races 10 of these ball bearings are fitted to the shaft 11 which extends longitudinally through the machine. Mounted upon the shaft 11 between the bearings are a plurality of disks 12 which are held in spaced relation by spacing collars 13 and are clamped in place between the end disks 14 which have outwardly extending hubs engaging the inner ends of the ball bearing races 10. Screw threaded to the shaft 11 are clamping nuts 15 arranged to draw these parts together to form a drum like rotor upon which the active elements of the machine are mounted. To the projecting end of this shaft 11 is attached a pulley 16 adapted to be connected through a suitable belt with any convenient source of rotative power to cause the rapid revolution of the rotor. Extending longitudinally of the shaft 11 and supported in apertures of the disks 12 and 14 are a plurality of pivot rods 17 upon each of which are pivotally mounted a plurality of arms 18 adapted, when the rotor rapidly revolves, to assume positions substantially radial to the center of such rotation. When this rotor is caused to revolve at high velocity the outer ends of the arms 18 will generate a substantially continuous cylindrical surface upon which the material to be pulverized will float during the process of pulverization, and which will be hereinafter referred to as the pulverizing surface. It will be noted from Fig. 2 of the drawings that in the illustrated rotor 6 axially extending rows of arms are provided. It will be noted that the visible arms of three of the rows are on one side of a plate 12 while the visible arms of the other three rows are on the other side of the same plate. It will be further evident from Figure 1 that the arms of each row are disposed between alternate pairs of plates and it follows from Fig. 2 that arms of the succeeding

row are disposed in the intervening spaces. Consequently, starting for example with the upper vertically extending arm of Fig. 2, moving to the left and downwardly to the next arm and moving downwardly to the second arm of the next row it will be seen that the arms of the various rows are so relatively disposed as to define spirals on the surface of the rotor.

The housing 2 consists essentially of a single casting and contains the feed hopper 19, the pulverizing and confining chamber 20 and the upper half of the cylindrical rotor chamber 21, all of which co-operate with the rotor to pulverize the material in the manner to be hereinafter described. The portion of the rotor chamber which is within the housing consists of end walls 22, and the rear side walls 23, formed of the housing casting, and a front wall 24 formed of a suitable curved plate which is adapted to be conveniently removed to permit the inspection of the interior parts of the machine. All of the interior surfaces of the casing which are exposed to the direct action of flying fragments of material during the pulverizing operation are protected with renewable plates of refractory metal as shown at 25, 26 and 27. Supported in suitable apertures of the casing are baffle bars 28, 29, 30 and 34 which extend longitudinally of the machine in close proximity to the path of travel of the reducing elements or pulverizing surface to intercept the travel of material with the pulverizing surface as will be more fully hereinafter explained. Under some circumstances, to insure against the presence of oversize material in the product, suitably spaced longitudinally extending grate bars 32 may be arranged beneath the rotor and supported in close proximity to the path of travel of the ends of the arms 18 by the flanges 33 formed on the end walls of the casing, to retain unpulverized fragments within the influence of the rapidly revolving arms 18 until such fragments are fully pulverized. As illustrated in the drawings the baffle bar 28 extends inwardly to a point in close proximity to the pulverizing surface its purpose being to prevent the tangential projection through the feed hopper of fragments of material which may be carried around by the rotor. This baffle bar 28 also forms the rearward limitation of the pulverizing chamber and is positioned approximately fifty degrees behind the longitudinal vertical central plane of the rotor, its sides being approximately parallel to the radius 38 of the rotor which passes through the center of said bar. Extending upwardly from the forward side of the bar 28 is an inclined chute 39 formed of a web of the housing casting, and upon this chute material slides into the pulverizing chamber. At its upper end the chute 39 is turned forwardly in a volute 40 by which fragments of material thrown from the pulverizing chamber will be intercepted and returned thereto. The baffle bar 29 forms the forward limitation of the pulverizing chamber and is positioned approximately ten degrees in advance of the central vertical plane of the rotor, its sides being inclined about fifteen degrees from the vertical, as indicated by the line 29a in Fig. 4. The forward wall of the pulverizing chamber is formed by a web 41 of the housing casting, extends upwardly as a continuation of the line 29a and is curved rearwardly to form a helical scroll 42 the end of which is turned directly downward. Formed on the upper part of the scroll 42 is an inclined flange 43 to which is attached a plate 44 which co-operates with the chute 39 to form the feed hopper 19, and which is adapted for adjustment in the direction of its length to vary the vertical distance of the throat of the feed hopper from the pulverizing surface to regulate the flow of material into the pulverizing chamber. As shown in Fig. 2 material from the feed hopper 19 slides down the chute 39 into the pulverizing chamber and floats upon the so called pulverizing surface to be pulverized thereby.

Under normal operating conditions the rotor of the machine here illustrated revolves at approximately two thousand revolutions per minute, causing the arms to assume a substantially radial position, their ends describing a circular orbit which is indicated by the broken line 45 in Fig. 4. At such speed the arms pass a given point in the orbit at the rate of twelve thousand per minute, or two hundred per second. Under these conditions, and making no allowance for the width of the arms 18, an unsupported block of material 46 immediately above and adjacent to the orbit 45, when acted upon by gravity only, will fall approximately five thousandths of an inch after the passage of one arm before the arrival of the next. Consequently the so called pulverizing surface should not be considered as a true cylinder but rather as composed of saw tooth shaped corrugations having a radial depth of five thousandths of an inch and a circular pitch of one sixth the circumference of the pulverizing cylinder, as indicated by the broken line 47 in Fig. 4. As the cylinder revolves these corrugations engage the block 46, chipping off minute particles of the material and tending to carry the entire block forwardly. As the engagement of the block 46 is below its center of gravity and its forward movement is resisted by its inertia, there is produced a rapid rotation of such block about its center of gravity, causing the corrugations of the pulverizing cylinder to contact with new points of engagement on the block 46, chipping off minute fragments at each contact, and reducing the block to a spherical form of ever decreasing dimensions. As the whirling block 46 is carried forward by the rotor it is intercepted by the baffle bar 29 as

indicated at 48 in Fig. 4, producing a reaction similar to the carom of a billiard ball, which causes the said block to fly away from the rotor surface, following around the scroll 42, as illustrated at 49 and 50, by which it is immediately returned to the pulverizing surface for further action. The inertia of the pivoted arms 18 cause them to lag slightly behind the true radial lines, as illustrated at 18a in Fig. 4, and each contact with material in the pulverizing chamber increases this tendency to lag. The amount of lag varies directly with the character of the material and the weight of the fragments. This rearward inclination of the arms 18, in conjunction with the forward inclination of the surface 41 at the lower end of the scroll 42, increases the upward reaction upon the block of material, thereby insuring the travel of the larger and heavier fragments around the scroll 42. Should the depth of material upon the pulverizing surface be sufficient to prevent the independent rotation of the blocks of material upon the pulverizing surface, and to also prevent their being thrown away from the rotor surface against the scroll 42, the entire mass of material will lie quiescent upon the pulverizing surface, in the manner of a brake shoe, exerting a much greater retarding effect than is produced while the fragments are free to roll upon the pulverizing surface. When the fragments of material are thus held against freedom of movement the ends of the arms 18 will exert a cutting action similar to that of a planer tool, as illustrated in Fig. 5, materially increasing the power consumption and decreasing the amount of the product. There is also a tendency, when too great a volume of material is fed into the pulverizing chamber, for such material to form an arch above the pulverizing surface, and entirely prevent further pulverizing action. Experience has demonstrated that the most efficient operation is obtained when the line 51, drawn from the lower edge of the adjustable feed plate 44 to the surface of the pulverizing cylinder at the vertical central plane of the machine, coincides with the angle of repose of the material being pulverized. As the angle of repose is different for different characters of material it will be found necessary, in order to attain maximum efficiency, to change the adjustment of the feed plate 44 to suit the characteristics of each different material which is to be pulverized. With suitable adjustment of the feeder plate 44 the amount of material in the pulverizing chamber will be so regulated that violent agitation of the fragments may be maintained, while the maximum number of fragments will be in contact with the pulverizing cylinder, thereby producing a maximum quantity of product with a minimum of power consumption.

It will be seen that by combining the closed retaining or combining chamber with the reducing elements in the manner shown and described, and preventing the escape of unreduced material from the zone of action of the reducing elements, the material will be retained in the confining chamber and in violent agitation under the action of the high speed rotor, and returned repeatedly by the end and top walls of the confining chamber to the reducing elements. This maintaining of the material under constant and repeated action by the reducing elements and preventing the escape of reduced material into the screening casing below the rotor, results in a uniformity of product and complete reduction of the material.

It is apparent that the depth of the corrugations of the pulverizing cylinder will vary directly with the speed of revolution of the rotor, having greater depth with lower speed of revolution, and it has been found that the fineness of the product bears a very close relation to the speed of the rotor, it being finer as the speed is increased.

The baffle bars 28, 29, 30, and 34 are of polygonal cross section, it will be be noted, and are supported in apertures in the side walls of the casing, the apertures being of similar cross section to that of the bars, in order to prevent their rotation. When the bars are in position, the apertures are closed by means of removable plates 31. Referring to bar 29, for instance, it will be seen that it presents a deflecting edge (its lower right hand edge) in close proximity to the periphery of the rotor. When this edge becomes unduly worn in use, plate 31 may be removed, bar 29 withdrawn from its supporting seats, and reinserted, with the new edge in deflecting position.

In the apparatus above described I have produced an improved pulverizing machine of simple and durable construction, economical of operation, and capable of pulverizing material varying in character from such material as oats and similar light grains, to limestones of quarry size.

What I claim is:

1. In a pulverizing machine, the combination with a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, of a pulverizing chamber entirely above the rotor, means to feed material to be pulverized upon the pulverizing surface within the pulverizing chamber and permit it to freely float thereon, and means to prevent the escape of unpulverized material from said pulverizing chamber.

2. In a pulverizing machine, the combination with a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, of a pulverizing chamber entirely above the rotor, means at the rearward side of the pulverizing chamber to feed material upon the

pulverizing surface and permit it to freely float thereon, means at the forward side of said chamber to prevent the escape of unpulverized material from said pulverizing chamber, and means to limit and control the amount of material admitted to the pulverizing chamber.

3. In a pulverizing machine, the combination with a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, a pulverizing chamber entirely above said rotor, means at the rearward side of the pulverizing chamber to feed material upon the pulverizing surface and permit it to freely float thereon, and means at the forward side of said pulverizing chamber to prevent the escape of unpulverized material from said pulverizing chamber.

4. In a pulverizing machine, the combination with a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, of a pulverizing chamber entirely above said pulverizing surface, means to feed material within the pulverizing chamber upon the pulverizing surface and to permit it to freely float thereon and means at the forward side of the pulverizing chamber to prevent the escape of unpulverized material from the pulverizing chamber and to return unpulverized fragments of material towards the rearward part of said pulverizing chamber to be again acted upon by the pulverizing surface.

5. In a pulverizing machine, the combination with a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, a pulverizing chamber above said rotor, an inclined chute at the rearward side of the pulverizing chamber upon which material may slide to the pulverizing surface the outer end of said chute terminating in a forwardly disposed scroll adapted to intercept fragments of material thrown from the pulverizing chamber and return them thereto.

6. In a pulverizing machine, the combination with a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, a pulverizing chamber above said rotor, an inclined chute at the rearward side of said pulverizing chamber upon which material may slide to the pulverizing surface, and a gate for controlling the discharge from said chute.

7. In a pulverizing machine, the combination of a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, a pulverizing chamber above said rotor, a baffle at the forward side of the pulverizing chamber in close proximity to and above the horizontal axis of said rotor to intercept advancing unpulverized fragments of material, and means to direct the material intercepted by said baffle rearwardly to the pulverizing surface.

8. In a pulverizing machine, the combination of a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, a pulverizing chamber above said rotor, and means substantially at the top of the path of movement of said rotor to confine the unpulverized material to the upper side of said rotor and prevent its passing downwardly into the throat of the machine while permitting it to float freely on said rotor.

9. In a pulverizing machine, the combination with a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, a pulverizing chamber above said rotor positioned and arranged to confine the unpulverized material in the upper side of said pulverizing cylinder while permitting it to freely float thereon, an inclined chute at the rearward side of said pulverizing chamber upon which material may slide to the pulverizing surface, an oppositely inclined plate co-operating with said chute to form a feed hopper above said pulverizing surface said plate being adjustable to vary its vertical distance from the pulverizing surface.

10. In a pulverizing machine, the combination of a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, of a pulverizing chamber above said rotor, an inclined wall at the rear side of said pulverizing chamber to deliver material to be pulverized to the pulverizing surface and permit it to float freely thereon, and a curved wall to receive and direct the material projected forwardly by the rotor upwardly and rearwardly to the pulverizing surface.

11. In a pulverizing machine, the combination of a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, of a pulverizing chamber above said rotor, an inclined wall at the rear side of said pulverizing chamber to deliver material to be pulverized to the pulverizing surface and permit it to float freely thereon, and a wall having a curved vertically disposed section and a curved rearwardly extending top section to receive and direct the material projected forwardly by the rotor upwardly and rearwardly to the pulverizing surface.

12. In a pulverizing machine, the combination of a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, a pulverizing chamber above said rotor, means at the rear side of said chamber to direct material to be pulverized to said rotor and permit it to float freely thereon, a wall at the

forward side of said chamber having a continuous upwardly and rearwardly curved surface to intercept unpulverized material and return it to the rear side of said chamber, and a baffle between the path of the rotor and said intercepting and returning means to prevent the passage of unpulverized material downwardly with the rotor.

13. In a pulverizing machine, the combination of a rotor adapted to revolve about a horizontal axis and having a substantially continuous cylindrical pulverizing surface, a pulverizing chamber above said rotor, means at the rearward side of said chamber to deliver material to be pulverized to the pulverizing surface and permit it to float freely thereon, means at the forward side of said pulverizing chamber to receive and direct the material projected forwardly by the rotor upwardly and rearwardly and return it to the rear side of said chamber, and a baffle located between the path of movement of said rotor and said directing and returning means to prevent the unpulverized material passing downwardly with the rotor.

14. In a machine of the class described, the combination of a rotor, a plurality of reducing elements disposed circumferentially of said rotor and which, when the rotor is in motion, generate a substantially continuous revolving material supporting surface; a casing closely surrounding the lower and major part of said rotor and having an outlet for reduced material, an enclosing hopper for the material to be reduced arranged above and closely embracing, at its lower end, said rotor to retain the material in floating condition on said rotor; and a material engaging abutment at substantially the junction of said casing and hopper disposed in close relation to the path of rotation of said reducing elements to permit the passage of completely reduced material only, said abutment having its material engaging face inclined to the vertical to deflect unreduced material upwardly and away from the rotor.

15. In a machine of the class described, the combination of a rotor, a plurality of reducing elements disposed circumferentially of said rotor and which, when the rotor is in motion, generate a substantially continuous revolving material supporting surface; a casing closely surrounding the lower and major part of said rotor and having an outlet for reduced material; an enclosing hopper for the material to be reduced arranged above and closely embracing, at its lower end, said rotor to retain the material in floating condition on said rotor; and a material engaging abutment arranged substantially at the point of junction of said hopper and casing and extending in substantially radial lines close to the path of rotation of said reducing elements.

16. In a machine of the class described, the combination of a rotor, a plurality of reducing elements disposed circumferentially of said rotor and which, when the rotor is in motion, generate a substantially continuous revolving material supporting surface; a casing closely surrounding the lower and major part of said rotor and having an outlet for reduced material; an enclosing hopper for the material to be reduced arranged above and closely embracing, at its lower end, said rotor to retain the material in floating condition on said rotor; and a removable material engaging abutment arranged substantially at the point of junction of said hopper and casing and extending in substantially radial lines close to the path of rotation of said reducing elements.

17. In a machine of the class described, the combination of a rotor, a plurality of reducing elements disposed circumferentially of said rotor and which, when the rotor is in motion, generate a substantially continuous revolving material engaging surface; a hopper to confine the material to be reduced within the zone of action of said reducing elements; and means in said hopper to direct unreduced material upwardly and rearwardly and return it for repeated action by said reducing instrumentalities.

18. In a machine of the class described, the combination of a rotor, a plurality of reducing elements disposed circumferentially of said rotor and which, when the rotor is in motion, generate a substantially continuous revolving material engaging surface; a hopper to confine the material to be reduced within the zone of action of said reducing elements, said hopper having its inner wall shaped to direct the unreduced material upwardly and rearwardly and return it for repeated action by said reducing instrumentalities.

19. In a machine of the class described, the combination of a rotor, a plurality of reducing elements disposed circumferentially of said rotor, and which, when the rotor is in motion, generate a substantially continuous revolving material engaging surface; a hopper to confine the material to be reduced within the zone of action of said reducing elements, said hopper having an upwardly and rearwardly curved inner wall to direct the unreduced material upwardly and rearwardly and return it for repeated action by said reducing instrumentalities.

20. In a machine of the class described, the combination of reducing instrumentalities, and a hopper provided with a material feeding chamber and a material confining chamber communicating with said feeding chamber, said confining chamber being provided with means to return the unreduced material to said reducing means.

21. In a machine of the class described, the combination of reducing instrumentalities,

and a hopper provided with a material feeding chamber and a material confining chamber communicating with said feeding chamber, said confining chamber having an upwardly and rearwardly curved wall to return the unreduced material to the reducing instrumentalities.

22. In a machine of the class described, the combination of reducing instrumentalities, and a hopper provided with a material feeding chamber and a material confining chamber communicating with said feeding chamber, said confining chamber having a scroll shaped inner wall to return the unreduced material to the reducing instrumentalities.

23. In a machine of the class described, the combination of reducing instrumentalities, a hopper provided with a material feeding chamber and a material confining chamber communicating with said feeding chamber, a top wall projecting partially across the top of said feeding chamber to prevent escape of material from said chamber, means in said confining chamber to return unreduced material in an upward and rearward direction to the reducing instrumentalities, and adjustable means between said chambers to regulate the feed of material from said feeding chamber to said confining chamber.

24. In a machine of the class described, the combination of reducing instrumentalities, a hopper provided with a material feeding chamber and a material confining chamber communicating with said feeding chamber, a curved top wall projecting partially across the top of said feeding chamber to prevent escape of material from said chamber, means in said confining chamber to return unreduced material in an upward and rearward direction to the reducing instrumentalities, and adjustable means between said chamber to regulate the feed of material from said feeding chamber to said confining chamber.

25. In a machine of the class described, the combination of reducing instrumentalities, a casing closely embracing a portion of said reducing instrumentalities, a hopper embracing the unencased portion of said reducing instrumentalities, and an abutment on each side of the unencased portion of said reducing instrumentalities extending in substantially radial lines close to the path of rotation of said reducing elements to prevent unreduced material passing from either side of said hopper into the casing.

26. In a machine of the class described, the combination of reducing instrumentalities, a casing closely embracing a portion of said reducing instrumentalities, a hopper embracing the unencased portion of said reducing instrumentalities, an abutment at substantially the points of junction of said hopper and casing on each side of the unencased portion of said reducing instrumentalities, and an abutment on each side of said reducing instrumentalities below said first named abutments to prevent unreduced material passing from either side of said hopper into the casing.

27. In a machine for reducing friable lump material, a rapidly travelling attritive body, means for confining a mass of feed material in operative contact with said body, and permitting the escape from such confined area of only the completely reduced material, and means for returning upwardly and rearwardly within said area the unreduced material displaced in the travelling direction of said body.

28. The new and improved method of reducing friable lump material which consists in developing a rapidly rotating field of reducing action, feeding a mass of the material into a certain section of said field of action, sustaining the mass by the centrifugal effect produced in said field of action, confining said mass to substantially said feeling section, and permitting the escape from said section of only the completely reduced material.

29. The new and improved method of reducing friable lump material which consists in developing a rapidly rotating field of reducing action, feeding a mass of material into a certain section of said field of action, sustaining the mass by the centrifugal effect produced in said field of action, confining said mass to substantially said feeding section, returning upwardly and rearwardly within said section the unreduced material displaced in the travelling direction of said field, and permitting the escape from said section of only the completely reduced material.

30. In a machine of the class described, a rotor comprising a plurality of reducing elements disposed circumferentially thereof, said elements generating a substantially continuous attritive surface when the rotor is in motion, means to confine a mass of material to be reduced in operative contact with said attritive surface, said means including an abutment element extending longitudinally of the rotor at the rearward limit of the confined mass in close proximity to said attritive surface, said abutment element having a substantially radial material obstructing and deflecting face to deflect unreduced material away from the rotor while permitting passage beyond said abutment element of completely reduced material.

31. In a device of the class described, a rotor, means for feeding material to be treated to the rotor, and means to confine the material to a certain section of the rotor, said means including a baffle bar of polygonal cross section extending substantially parallel to the rotor axis with a deflecting edge in close proximity to the rotor periphery, and supporting means for said bar, said bar being adjustable relative to said supporting

means whereby the bar may be disposed therein in a selected edge in deflecting position.

32. In a machine of the class described, the combination of a rotor; a plurality of circumferentially disposed reducing elements arranged spirally longitudinally of said rotor and which, when the rotor is in motion, generate a substantially continuous, revolving, material-supporting surface; and a hopper for the material to be reduced arranged above and closely embracing at its lower end said rotor to prevent oversize material passing between said rotor and the lower end of said hopper.

33. In a machine of the class described, the combination of a rotor; a plurality of radially extending reducing elements circumferentially disposed and spirally arranged longitudinally of said rotor and which, when the rotor is in motion, generate a substantially continuous, revolving material-supporting surface; and a hopper for the material to be reduced arranged above and closely embracing at its lower end said rotor to prevent oversize material passing between said rotor and the lower end of said hopper.

34. In a machine of the class described, the combination of a movable member; a plurality of reducing members carried by said member, and which, when the member is in motion, generate a substantially continuous, moving, material-engaging surface; a hopper for the material to be reduced closely embracing at its rear lower end portion said movable member and reducing elements to retain the material in floating condition on said reducing members and to prevent oversize material passing between said reducing elements and that end portion of said hopper; and an adjustably mounted material-engaging abutment projecting close to the path of movement of said reducing elements.

35. In a machine of the class described, the combination of a rotor, a plurality of reducing elements disposed circumferentially of said rotor, and which, when the rotor is in motion generate a substantially continuous, revolving, material-engaging surface; a hopper for the material to be reduced closely embracing at its lower rear end a portion of said rotor to retain the material in floating condition on said rotor and to prevent oversize material passing between the rotor and that end portion of said hopper; and an adjustably mounted material-engaging abutment projecting in substantially radial lines close to the path of rotation of said rotor.

36. In a machine of the class described, the combination of a rotor; a plurality of reducing elements disposed circumferentially of said rotor which, when the rotor is in motion, generate a substantially continuous revolving material-engaging surface; a hopper for the material to be reduced; a substantially vertical plate at the forward side of the hopper; and a laterally and inwardly projecting abutment at substantially the lower end of said plate.

37. In a machine of the class described, the combination of a rotor; a plurality of reducing elements disposed circumferentially of said rotor which, when the rotor is in motion, generate a substantially continuous revolving material engaging surface; a hopper for the material to be reduced; a substantially vertical plate at the forward side of the hopper; and a laterally and inwardly projecting abutment having a downwardly inclined upper surface at substantially the lower end of said plate.

In testimony whereof, I affix my signature.

WILLIAM KELSEY LIGGETT.