

June 11, 1963

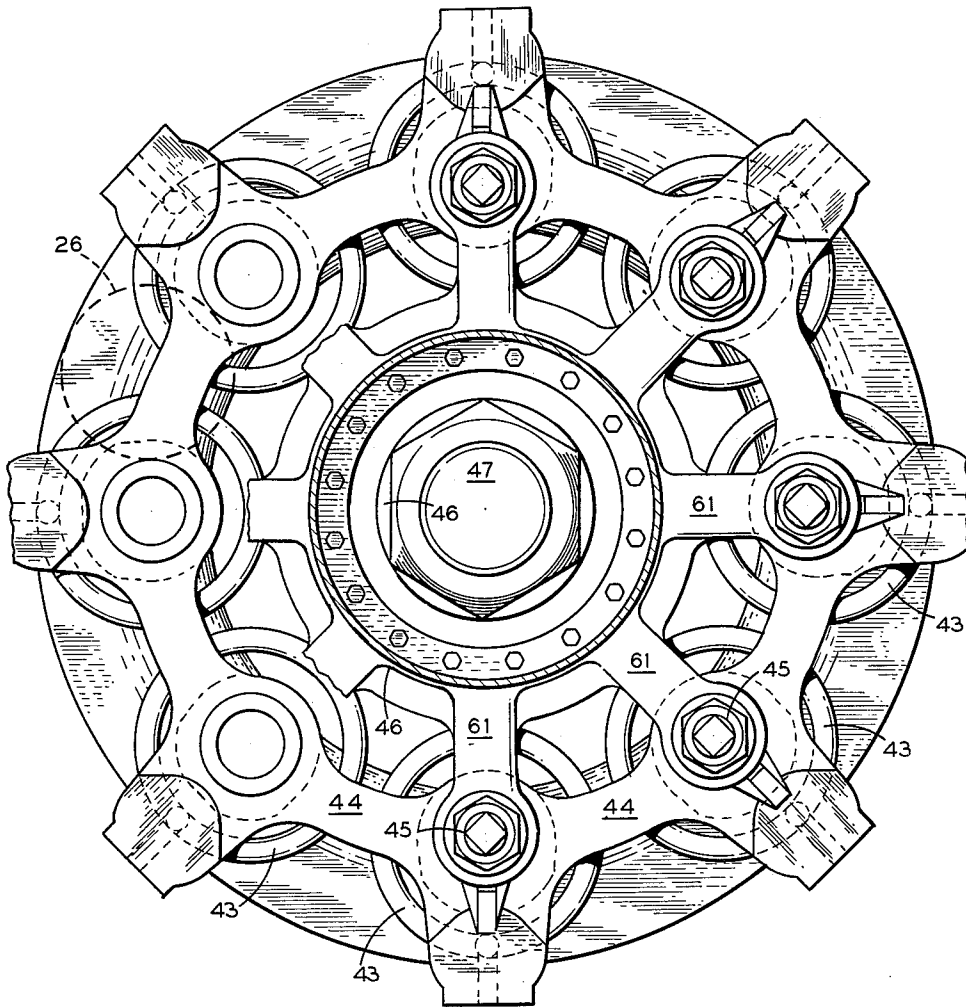
J. L. HARVEY ETAL
PULVERIZER

3,093,327

Filed May 29, 1962

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FIG.2



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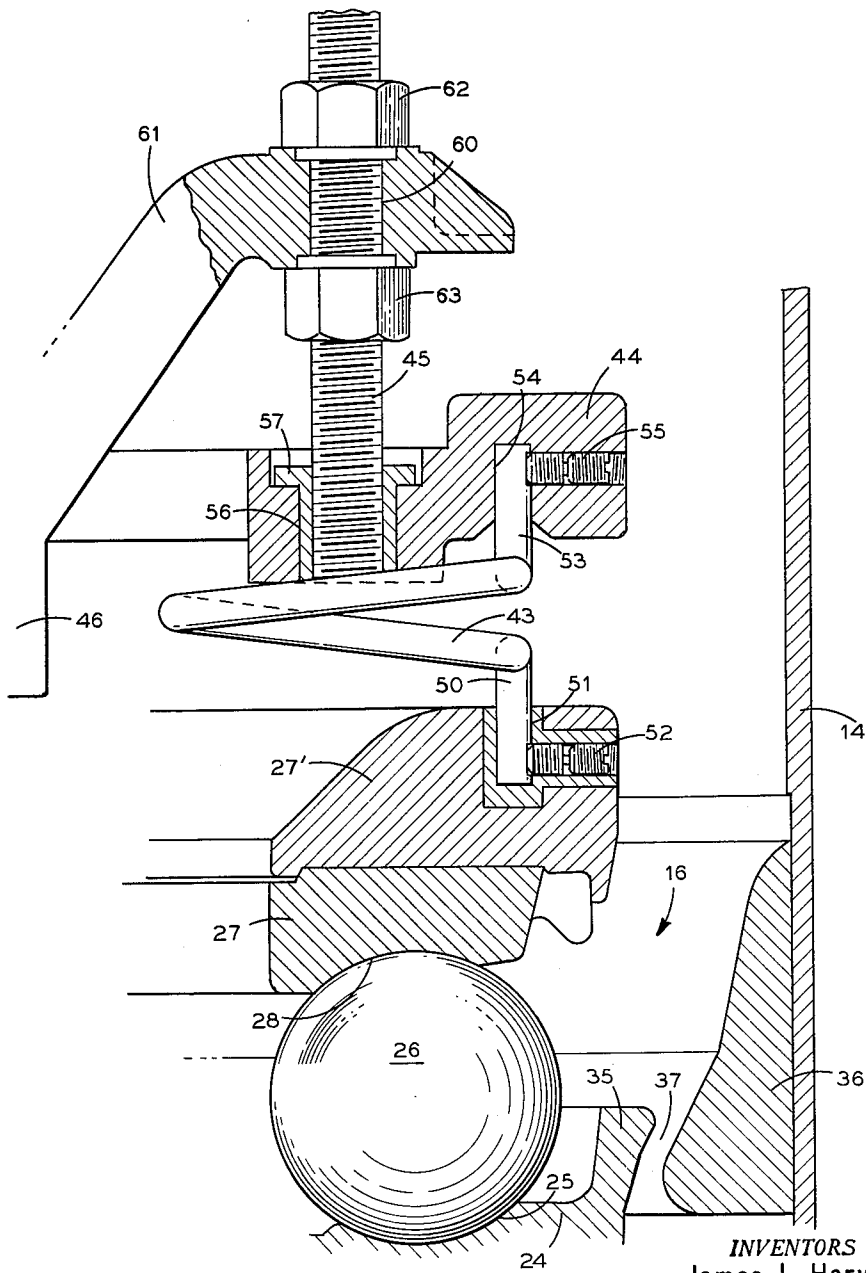
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FIG. 3



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PULVERIZER

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Filed May 29, 1962, Ser. No. 198,682
8 Claims. (Cl. 241-52)

This invention relates in general to improvements in the construction and operation of pulverizers, and more particularly to pulverizers in which a circular series of rolling grinding elements are positioned between relatively moving upper and lower grinding rings. The rings of the pulverizer are urged together to exert a pressure on the contacting surfaces of the rings and balls so that raw materials introduced generally into the grinding zone formed by the rings and balls will be pulverized in passing outwardly therethrough for discharge from the outer periphery of the zone. Certain features of the pulverizer disclosed in this application are disclosed and claimed in copending applications of Edward M. Poole, Serial No. 197,061, filed May 23, 1962, and of Neil W. Eft and Richard A. Miller, Serial No. 197,062, filed May 23, 1962.

In the present invention a pulverizer of the ring and ball type is provided wherein the upper and lower rings are rotated in opposite directions to increase the effective grinding area utilized in pulverization. The increased grinding area increases the capacity of the pulverizer without a corresponding increase in its size, and without increasing the centrifugal forces imposed on the rolling grinding elements operating between the rotating upper and lower rings. In a preferred form of the invention the rings are separately driven from separate motors located adjacent the lower portion of the pulverizer through concentric oppositely rotating, telescoping drive shafts. While the lower ring is directly driven from its drive shaft, the upper ring is rotated through a compression spring arrangement attached to a yoke member mounted on a drive shaft. The rates of rotation of the upper and lower rings are different so that the circular row of rolling grinding elements will rotate at a slow speed about the central axis of the ring drive shafts. The centrifugal forces imposed on such elements will be low while the effective grinding surface is high relative to the floor area occupied by the pulverizer.

The invention is particularly useful in a pulverizer arranged for air-swept service, as in preparing solid fuels, such as bituminous coal, for suspension burning. In such an arrangement, carrier air is passed upwardly in an annular stream around the periphery of the pulverizing elements or zone to entrain the discharged wholly and partially pulverized solids, which are thereafter classified in the upper portion of the pulverizer. The classification stage separates the desired finished product, for air-borne removal from the pulverizer, from the oversized materials which are returned to the grinding elements for further pulverization.

The various features of novelty which characterize our invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which we have illustrated and described a preferred embodiment of the invention.

Of the drawings:

FIG. 1 is an elevation, in section, of a pulverizer constructed and arranged in accordance with the present invention;

FIG. 2 is a section taken along line 2-2 of FIG. 1; and

FIG. 3 is an enlarged section of a portion of the pulverizer shown in FIG. 1.

In general, the pulverizer illustrated includes a cylindrical upper housing section 10 and a lower housing section 11 supported on a foundation 12. The sections 10 and 11 are fastened together for ease of assembly, and the section 10 may be made in two cylindrical portions 13 and 14 for ease of access to the grinding and classification zones hereinafter described. The lower housing section 11 encloses a gear housing 15 which is separately supported by the foundation 12. As hereinafter described the gear housing 15 contains two worm-gear speed reducers each connected to its respective drive shaft, one of which drives the lower grinding ring while the other drives the upper grinding ring, both rings being positioned within the pulverizing or grinding zone 16. Each worm-gear reducer is directly connected with a separate, externally positioned drive motor (not shown).

Raw coal supplied to a regulable feeder 17 discharges the coal into the grinding zone 16 through a chute 18 extending through the housing 10 from the feeder. Air, at superatmospheric pressure, enters the lower section 14 of the pulverizer housing 10 through an encircling duct 20, the pass upwardly adjacent the outer side or periphery of the grinding zone 16, entraining comminuted coal, and thence through a classifier or separator 21, with the airborne finished product leaving the pulverizer housing section 13 through a centrally located upper outlet 22. The oversized material is passed downwardly from the classifier 21 into an annular discharge port 23 for return to the pulverizing zone 16.

The grinding zone of the pulverizer includes a lower horizontally disposed grinding ring 24 having a circular groove or race 25 formed in its upper face to support a circular row of grinding balls 26 (see FIGS. 1 and 3). The balls in turn support an upper two piece grinding ring 27-27' which is provided with a circular groove or race 28 in its lower face engaging the circular row of balls. In accordance with this invention both the upper and lower grinding rings 27 and 24, respectively, are rotated, but in opposite directions and at different rates of rotation. The rate of rotation of the row of balls about the axis of ring rotation will generally be equal to one-half the difference between the rates of ring rotation. This low ball row rotation rate results in a low value of centrifugal force imposed on the balls while maintaining a high rate of application of grinding force or work on the material being pulverized in any unit of time, leading to extremely high rates of pulverization per unit of floor space occupied by the pulverizer.

The lower grinding ring 24 is provided with a flat lower face supported on and pinned to a T-shaped annular ledge member 30 and to the annular upper surface of a generally conical driving rotor 31, the shank 32 of the member 30 being interposed between the ring 24 and the rotor 31. The rotor 31 is affixed to the upper end portion of a stub shaft 33 which is rotated by a worm-gear drive assembly 34 positioned in the upper portion of the gear housing 15.

As shown in FIG. 1, the generally vertical arms of the member 30 extend above and below the shank 32. The upper arm 35 of the member 30 forms an upstanding ledge to restrict the flow of pulverized material from the grinding zone 16, while the outer surface of the arm 35 is shaped to cooperate with a vertically adjustable stationary ring member 36 in defining a throat 37 for directing the upward flow of entraining air within the grinding zone. As shown, the cooperating surfaces defining the throat 37 direct the entraining air upwardly and slightly outwardly toward the housing section 14 of the pulverizer. Thus, the air passing through the duct

20 enters the pulverizer housing section 14 through a vaned annular opening 38 discharging in an inward direction into a chamber 40 and thence upwardly through the throat. The chamber 40 is inwardly defined by the upper and lower arms 35 and 41, respectively of the rotating member 30, a lower fixed ring 42, and at the top by the lower portion of member 36, and in part by the throat opening 37. The ring 36 is provided with a spring loaded displaceable section (not shown) which will be forced outwardly toward the housing by foreign materials such as tramp iron, or the like. Such foreign materials will fall by gravity into chamber 40 and discharge downwardly into box 39, from which the materials may be periodically removed.

The upper ring 27 is rotated and urged downwardly against the row of balls by a plurality of circumferentially equally spaced single turn coil springs. In the embodiment shown, the springs 43 are attached to an annular member 44 which is supported by upright bolts 45, and a drive yoke 46 which is attached to the upper end portion of a shaft 47. The coil of each of the springs 43 is generally horizontally oriented and provided with oppositely extending upright end portions. The lower end extension 50 of each spring projects downwardly into a pocket or recess 51 formed in the upper outer portion of the ring 27 and is locked in place by a set screw 52. The opposite, or upper end extension 53 of each spring is fitted into a recess 54 formed in the lower portion of the member 44 and is locked in place by a set screw 55. Each of the recesses 51 and 54 are positioned in vertical alignment, and each spring 43 is arranged with its coil portion projecting inwardly and horizontally of the opposed end extensions 50 and 53 so as to leave clear the space between the member 44 and the housing 14 for upward movement of air entrained solids therethrough.

The member 44 is provided with circumferentially equally spaced openings 56 therethrough each of which receives a sleeve 57 and the lower end portion of a vertically adjustable bolt 45. Each of the bolts 45 is threaded and projects upwardly through an opening 60 formed in an arm 61 of the yoke 46, and is locked in an adjustable position relative to the arm by lock nuts 62 and 63.

In the construction described, the springs 43 are rigidly fixed with respect to the member 44 which in turn is vertically positioned with respect to the yoke 46 so that the grinding pressure exerted on the pulverizing zone 16 is adjustable. The springs are used to transmit a rotational movement to the upper ring 27 from the drive mechanism. Simultaneously they restrain lateral movement of the ring 27 during rotation and by reason of the flexibility of the springs permit a restrained tilting of the ring 27, as may be caused by the presence of foreign materials, such as tramp iron, in the pulverizing zone 16. The positional relationship of the member 44, bolts 45 and the yoke arms 61 is such as to minimize abrasion of the bolts 45 by the rising stream of pulverized material entrained in the air, which occurs particularly adjacent the housing 10, and minimizes the imposition of bending forces on the adjustable bolts 45. In effect the bolts can be considered fixed end beams due to their fixed relationship to the annular member 44 and the arms 61 of the yoke.

As shown in FIG. 1, the shafts 33 and 47 are coaxial, with the shaft 47 supported by thrust bearing 62 and radial bearing 63 engaging the gear housing 15. Immediately above the bearing 62 the shaft 47 is provided with a gear ring 64 which is bolted to a hub 65. The gear ring 64 engages a worm 66 driven by a motor (not shown) to transmit rotational movement to the shaft 47.

The shaft 33, driving the lower ring 24, is coaxial with and supported on the shaft 47 through combination thrust and radial bearing 70 and radial bearings 71 and 72. The radial bearing 71 maintains the axial relationship of the shaft 33 with respect to the gear housing 15 while the radial bearing 72 maintains the coaxial relationship be-

tween shafts 47 and 33. The drive arrangement 34 includes a worm 73 driven by a motor (not shown) and drivingly engaging a worm-gear 74 affixed to the shaft 33.

The worm-gear drives and the bearings are suitably lubricated by high pressure oil. The uppermost bearing 72 is supplied with lubricating oil which is pumped upwardly through a centrally positioned bore 98 in the shaft 47, to discharge through radially located discharge passageways 99 directly to the bearing. Oil from the bearing 72 flows downwardly between the shafts 47 and 33 to supply the lower bearing 70. Since the bearing 71 is mounted between the gear housing 15 and the shaft 33, the bearing is directly lubricated from the gear housing.

With the upper portions of both of the shafts extending into the housing 10 and being exposed to the material-laden air therein, it is necessary to protect the bearing lubrication and bearing surfaces by a suitable air seal arrangement. Sealing air enters through a pipe 75 extending through the housing section 11 with a connecting duct 76 ending in an annular plenum chamber 79 adjacent the external surface of the rotating member 31. The member 31 is drilled to form air flow passageways 78 parallel to the axis thereof with the upper end opening into a rotating chamber 77 affixed to the upper end of shaft 33, while the lower end of the passageways are each provided with an outwardly opening radial extension 80 which is located at the level of the chamber 79. With the construction described, sealing air is introduced into the pipe 75 at a pressure in excess of the pressure prevailing within the pulverizer and passes from chamber 79 upwardly through the passageway 78 into the chamber 77. Any sealing air which escapes from the plenum chamber 79 between the rotating and stationary parts thereof discharges either downwardly and into the atmosphere or upwardly into the pulverizer housing beneath the member 31. The latter portion of escaping seal air eventually passes between the outer end of the arm 41 and the inner end of the part 42, and thus mingles with the carrier air passing through the chamber 40.

Since the chamber 77 rotates with the shaft 33 a running clearance is formed between the upper and lower walls 81 and 82, respectively, of the chamber so that some of the sealing air will escape in the space between the shaft 47 and the upper wall 81 into the interior of the pulverizer housing 10. The outward flow of such sealing air will prevent infiltration of dust-laden air into the bearings of the pulverizer drive shafts. The remainder of the sealing air delivered to the chamber 77 will discharge downwardly along the shaft 47, between the shaft and the end of the wall 82, into a chamber 83 and thence through one or more passageways 84 in member 31 into a space 85 beneath a stationary diaphragm plate 86 which forms the lower wall of the pulverizer housing section 14. The space 85 defined by the diaphragm 86 and the top of the gear housing 15 is open to the atmosphere.

The mixture of pulverized material and air passing upwardly in an annular stream adjacent the inner wall of the housing sections 13 and 14 enters the classifier 21 through a series of circumferentially disposed angularly positioned upright vanes 90 located downwardly adjacent the upper plate 91 forming the top of the pulverizer housing. The vanes 90 are attached to the plate 91 and are provided with adjustable end portions 90A which may be extended or retracted to alter the fineness characteristics of the finished product. The lower edges of the vanes 90 are attached to the base flange of an inverted frustoconical member 92 extending downwardly to the annular opening 23 for the discharge of separated coarser solid materials from the classifier 21. The opening 22 in the top of the pulverizer is provided with a depending duct 94 extending downwardly into the classifier and thereby providing an outlet for air-borne classified material to leave the pulverizer housing 10. The lower end of the duct 94 is provided with an adjustable cylindrical member 95 which embraces the duct 94 and is vertically adjust-

able for a relatively minor regulation of the fineness limits of the materials discharged from the pulverizer.

As shown, the inner side of the lower annular classifier discharge opening 23 is defined by a cylindrical cap member 96 which is attached to the yoke 46 and rotates therewith. The cap member protects the upper end of the shaft 47, and the yoke 46 attachment to the shaft, and provides a support for a vaned rotor 97 operating in the opening 23 to reduce the "back flow" or leakage of airborne materials upwardly through the opening.

It will be noted all of the rotating parts, with the exception of the worm drives and their shafts, are arranged in a closed stress loop to minimize vibration and mechanical stress on the rotating parts. The pressure exerted on the rings and balls by the springs 43 is contained within the coaxially arranged shafts 47 and 33, and the combined radial and thrust bearing 70. Thus the upward thrust of the member 44, as caused by the compression of the springs 43 and by operation of the grinding zone, is transmitted through the bolts 45 and arms 61 to the shaft 47, and results in an upward thrust against the bearing 70. At the same time the downward thrust on the ring 27 from the springs 43 is transmitted through the balls 26, ring 24 and yoke 31 to the shaft 33 and results in a downward thrust against the bearing 70. Generally speaking, the net downward thrust at the bearing 70 will be substantially equal to the dead weight of the assembly of the rotating parts so that the lower thrust bearing 62 need only be sized to support the dead weight of the rotating parts.

In the embodiment of the invention, the pulverizer is rated for a grinding capacity of 50 tons per hour of a medium low grindability bituminous coal at a product fineness of 70% passing the 200 mesh U.S. Standard screen. To attain this capacity the pitch diameter of the grinding zone is 77 inches, the shaft 33 is rotated at 62 r.p.m. and shaft 47 is rotated at 82 r.p.m.

While in accordance with the provisions of the statutes we have illustrated and described herein the best form and mode of operation of the invention now known to us, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by our claims, and that certain features of our invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. A pulverizer comprising a housing enclosing a pulverizing zone, said pulverizing zone including horizontally disposed upper and lower grinding rings, a horizontally disposed circumferential row of rolling grinding elements positioned between said upper and lower rings, means for rotating said upper grinding ring including an upright shaft having its upper end projected above said upper grinding ring and its lower end projected below said housing, a gear housing positioned below said housing to enclose the lower portion of said shaft, drive means for rotating said shaft, adjustably resilient means for connecting the upper portion of said shaft with said upper grinding ring to transmit the rotation of said shaft to said upper grinding ring and to exert a downward pressure on said upper ring including a yoke mounted on the upper end portion of said shaft, a horizontally disposed annular member radially spaced from and encircling said yoke, means for adjustably positioning said member relative to said upper grinding ring and means for resiliently connecting said member and upper grinding ring, means for discharging material to be pulverized into said pulverizing zone, and means for withdrawing pulverized material from said pulverizer.

2. A pulverizer comprising a housing enclosing a pulverizing zone, said pulverizing zone including horizontally disposed upper and lower grinding rings, a horizontally disposed circumferential row of rolling grinding elements positioned between said upper and lower rings, means

for rotating said upper grinding ring including an upright shaft having its upper end projected above said upper grinding ring and its lower end projected below said housing, a gear housing positioned below said housing to enclose the lower portion of said shaft, drive means for rotating said shaft, means including coil springs for connecting the upper portion of said shaft with said upper grinding ring to transmit the rotation of said shaft to said upper grinding ring, a hollow shaft coaxial with and encircling the intermediate portion of said first named shaft, the lower end portion of said hollow shaft extended into said gear housing and having its lower end bearing on a shoulder formed on said first named shaft, drive means for rotating said hollow shaft in a direction opposite to the direction of rotation of said first named shaft, and a frusto-conical yoke secured to the upper end portion of said hollow shaft and supporting said lower grinding ring for rotation with said hollow shaft.

3. A pulverizer comprising a housing enclosing a pulverizing zone, said pulverizing zone including horizontally disposed upper and lower grinding rings, a horizontally disposed circumferential row of rolling grinding elements positioned between said upper and lower rings, means for rotating said upper grinding ring including an upright shaft having its upper end projected above said upper grinding ring and its lower end projected below said housing, a gear housing positioned below said housing to enclose the lower portion of said shaft, drive means for rotating said shaft, flexible means for connecting the upper portion of said shaft with said upper grinding ring to transmit the rotation of said shaft to said upper grinding ring and to exert a downward pressure on said upper ring, a hollow shaft coaxial with and encircling the intermediate portion of said first named shaft, the lower end portion of said hollow shaft extended into said gear housing and having its lower end bearing on a shoulder formed on said first named shaft, a combined radial and thrust bearing between said hollow shaft and said shoulder, drive means for rotating said hollow shaft in a direction opposite to the direction of rotation of said first named shaft, and a frusto-conical yoke secured to the upper end portion of said hollow shaft and supporting said lower grinding ring for rotation with said hollow shaft.

4. A pulverizer comprising a housing enclosing a pulverizing zone, said pulverizing zone including horizontally disposed upper and lower grinding rings, a horizontally disposed circumferential row of rolling grinding elements positioned between said upper and lower rings, means for rotating said upper grinding ring including an upright shaft having its upper end projected above said upper grinding ring and its lower end projected below said housing, a gear housing positioned below said housing to enclose the lower portion of said shaft, drive means for rotating said shaft, means including coil springs for connecting the upper grinding ring to transmit the rotation of said shaft to said upper grinding ring, a hollow shaft coaxial with and encircling the intermediate portion of said first named shaft the lower end portion of said hollow shaft extended into said gear housing and having its lower end bearing on a shoulder formed on said first named shaft, drive means for rotating said hollow shaft in a direction opposite to the direction of rotation of said first named shaft, a frusto-conical yoke secured to the upper end portion of said hollow shaft and supporting said lower grinding ring for rotation with said hollow shaft, air seal means attached to the upper end of said hollow shaft and encircling said first named shaft, and means for introducing seal air to said air seal means at a higher pressure than that prevailing in said pulverizer housing to cause outward air flow from said air seal means.

5. A pulverizer comprising a housing mounted upon a foundation member and enclosing a pulverizing zone, said pulverizing zone including horizontally disposed upper and lower grinding rings, a horizontally disposed circum-

ferential row of rolling grinding elements positioned between said upper and lower rings, means for rotating said upper grinding ring including an upright shaft having its upper end projected above said upper grinding ring and its lower end projected below said housing, a gear housing positioned below said housing to enclose the lower portion of said shaft, said gear housing separately mounted on the foundation member of said housing drive, means for rotating said shaft, means including single turn coil springs for connecting the upper portion of said shaft with said upper grinding ring to transmit the rotation of said shaft to said upper grinding ring, a hollow shaft coaxial with and encircling the intermediate portion of said first named shaft, the lower end portion of said hollow shaft extended into said gear housing and having its lower end bearing on a shoulder formed on said first named shaft, drive means for rotating said hollow shaft in a direction opposite to the direction of rotation of said first named shaft, a frusto-conical yoke secured to the upper end portion of said hollow shaft, a spacer member mounted on said yoke and directly supporting said lower grinding ring for rotation with said hollow shaft.

6. A pulverizer comprising a housing enclosing a pulverizing zone, said pulverizing zone including horizontally disposed upper and lower grinding rings, a horizontally disposed circumferential row of rolling grinding elements positioned between said upper and lower rings, means for rotating said upper grinding ring including an upright shaft having its upper end projected above said upper grinding ring and its lower end projected below said housing, a gear housing positioned below said housing to enclose the lower portion of said shaft, drive means for rotating said shaft, adjustably resilient connecting the upper portion of said shaft with said upper grinding ring to transmit the rotation of said shaft to said upper grinding ring including a yoke on the upper end portion of said shaft, an annular member spaced outwardly of said yoke and immediately above said upper ring, means rigidly connecting said yoke and said annular member for vertical adjustment therebetween, and resilient means connecting said annular member and said upper grinding ring, a hollow shaft coaxial with and encircling the intermediate portion of said first named shaft, the lower end portion of said hollow shaft extended into said gear housing and having its lower end bearing on a shoulder formed on said first named shaft, drive means for rotating said hollow shaft in a direction opposite to the direction of rotation of said first named shaft, and a frusto-conical yoke secured to the upper end portion of said hollow shaft and supporting said lower grinding ring for rotation with said hollow shaft.

7. A pulverizer comprising a housing enclosing a pulverizing zone, said pulverizing zone including horizontally disposed upper and lower grinding rings, a horizontally disposed circumferential row of rolling grinding elements positioned between said upper and lower rings, means for rotating said upper grinding ring including an upright shaft having its upper end projected above said upper

grinding ring and its lower end projected below said housing, a gear housing positioned below said housing to enclose the lower portion of said shaft, drive means for rotating said shaft, means including a plurality of coil springs for connecting the upper portion of said shaft with said upper grinding ring to transmit the rotation of said shaft to said upper grinding ring and to impose a resilient downward pressure on said pulverizing zone, a hollow shaft coaxial with and encircling the intermediate portion of said first named shaft, the lower end portion of said hollow shaft extended into said gear housing and having its lower end bearing on a shoulder formed on said first named shaft, drive means for rotating said hollow shaft in a direction opposite to the direction of rotation of said first named shaft, a frusto-conical yoke secured to the upper end portion of said hollow shaft and supporting said lower grinding ring for rotation with said hollow shaft, air seal means attached to the upper end of said hollow shaft and encircling said first named shaft, and means for introducing seal air to said air seal means at a higher pressure than that prevailing in said pulverizer housing to cause restricted flow air from said air seal means into said pulverizer housing.

8. A pulverizer comprising a housing mounted upon a foundation member and enclosing a pulverizing zone, said pulverizing zone including horizontally disposed upper and lower grinding rings, a horizontally disposed circumferential row of rolling grinding elements positioned between said upper and lower rings, means for rotating said upper grinding ring including an upright shaft having its upper end projected above said upper grinding ring and its lower end projected below said housing, a gear housing positioned below said housing to enclose the lower portion of said shaft, said gear housing separately mounted on the foundation member of said housing drive, means including single turn coil springs for connecting the upper portion of said shaft with said upper grinding ring to transmit the rotation of said shaft to upper grinding ring, a hollow shaft coaxial with and encircling the intermediate portion of said first named shaft, the lower end portion of said hollow shaft extended into said gear housing and having its lower end bearing on a shoulder formed on said first named shaft, separate drive means for rotating said hollow shaft and said first named shaft in an opposite direction and at different rates of rotation, a frusto-conical yoke secured to the upper end portion of said hollow shaft, a spacer member mounted on said yoke and directly supporting said lower grinding ring for rotation with said hollow shaft.

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