June 7, 1955 J. B. WALKER, JR 2,710,148

PULVERIZER GRINDING RINGS

Filed Feb. 12, 1952 2 Sheets-Sheet 1

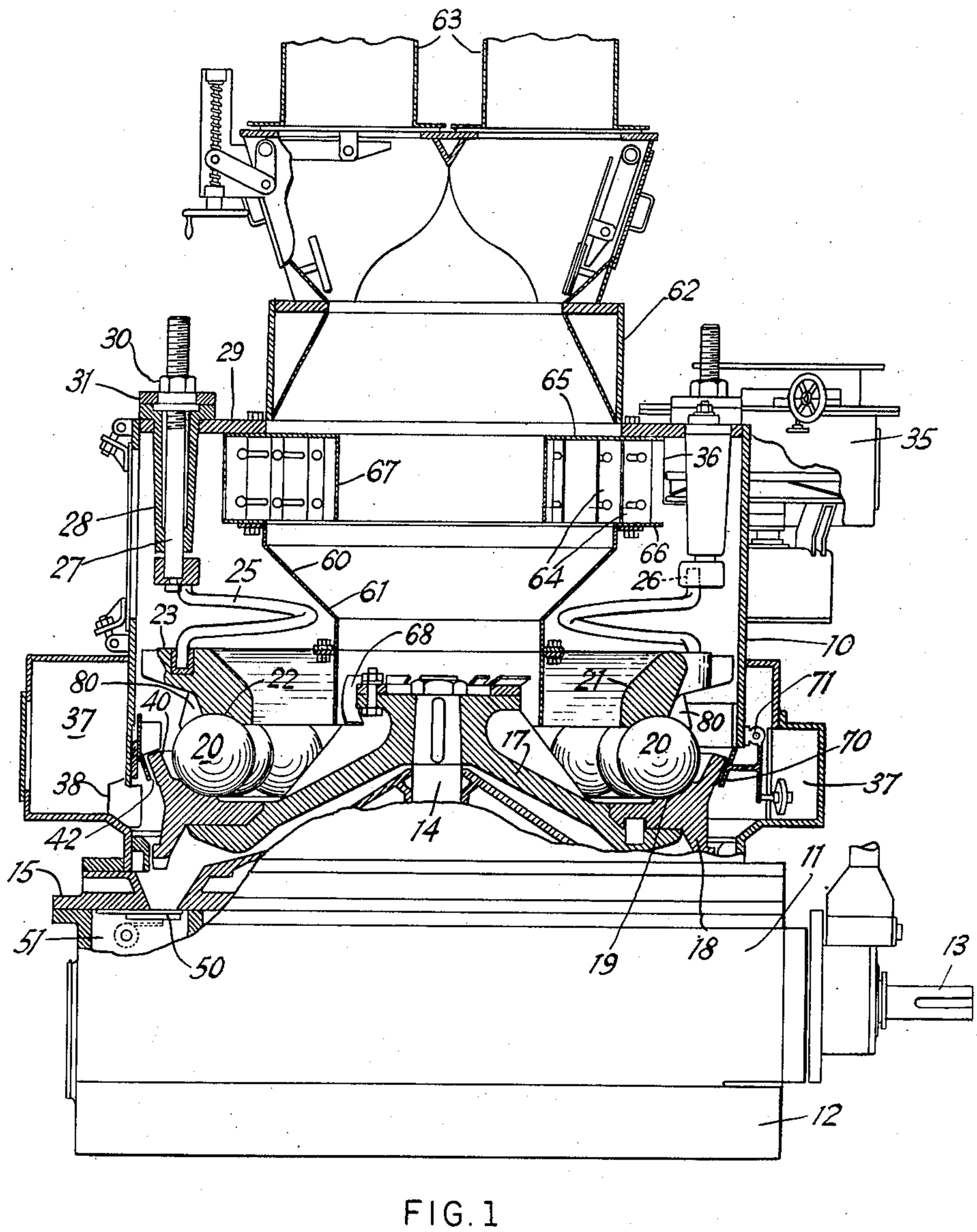

FIG. 1

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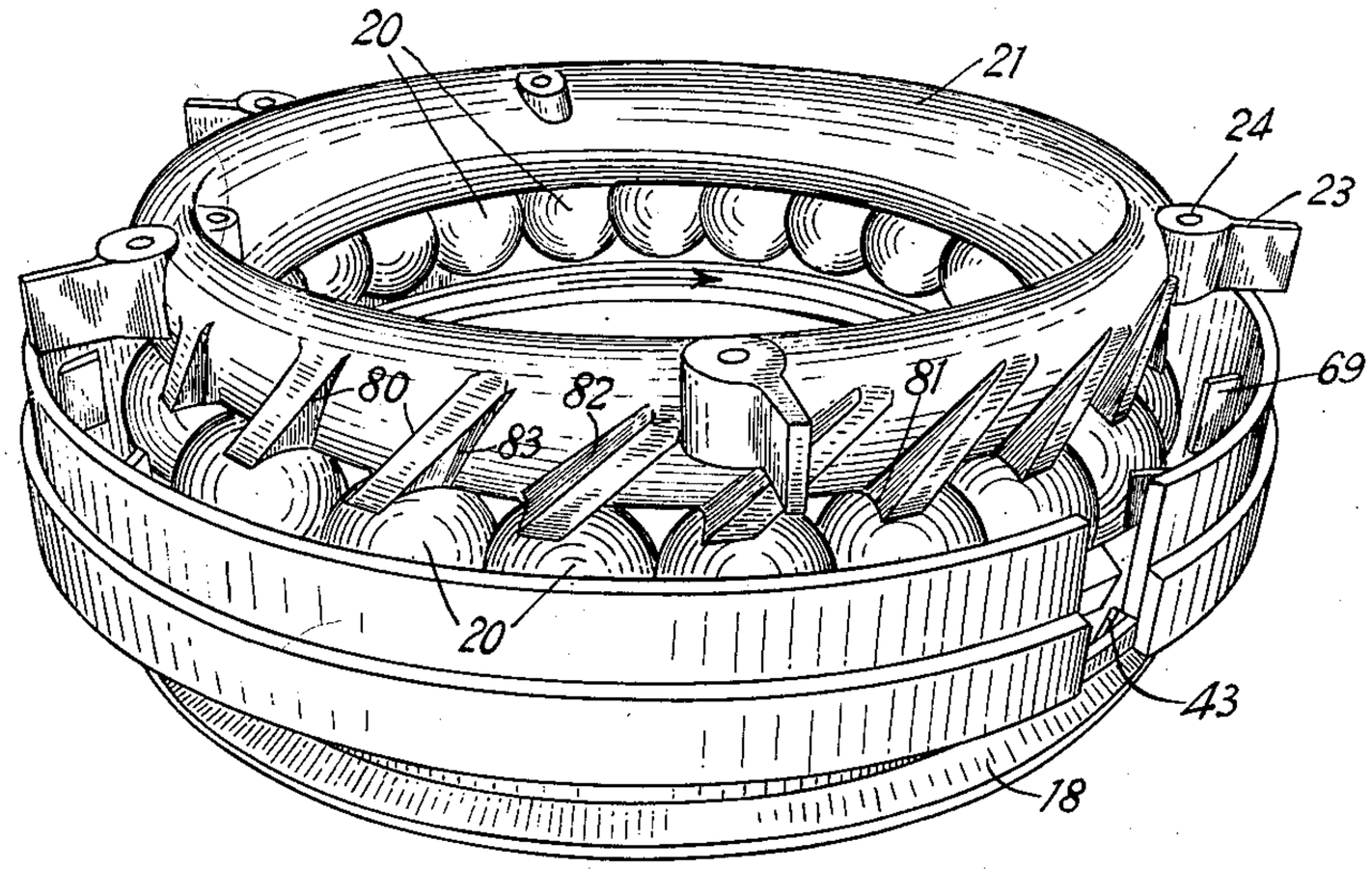

FIG. 2

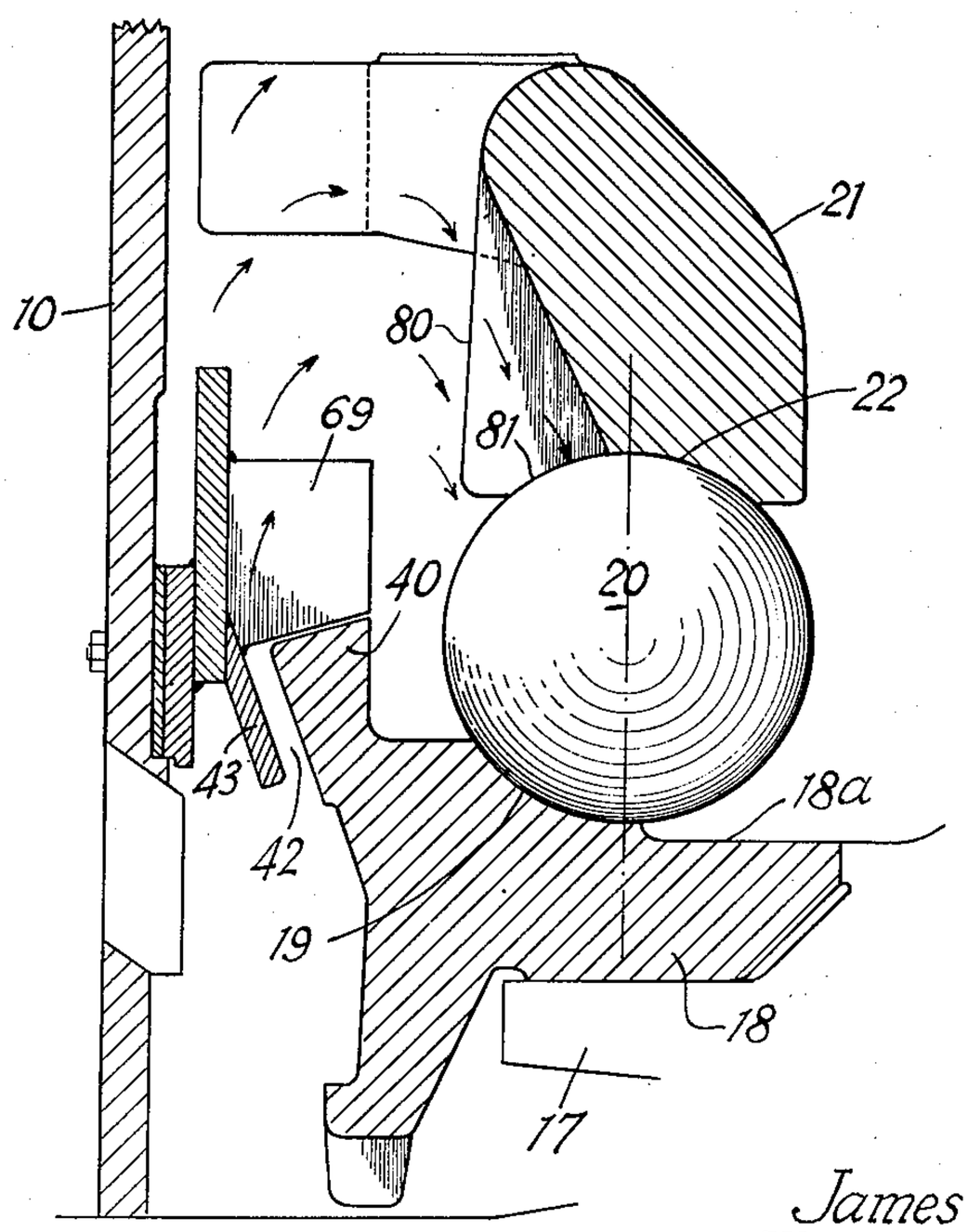

FIG. 3

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PULVERIZER GRINDING RINGS

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Application February 12, 1952, Serial No. 271,133

7 Claims. (Cl. 241—52)

The present invention relates in general to improvements in the construction and operation of pulverizers, and more particularly, to pulverizers of the general type shown in U. S. Patent No. 2,275,595 in which a housing encloses a horizontally arranged circular series of rolling grinding elements positioned between cooperating upper non-rotating and lower rotary grinding rings resiliently pressed together, the raw material to be pulverized being delivered to the inner side of the annular grinding zone, and most of the wholly or partly pulverized material swept up at the outer side of the grinding zone by a high velocity annular stream of a gaseous carrier medium passing upwardly through an annular throat. Any particles of sufficient density to drop through the throat against the carrier gas stream are collected in the subjacent part of the pulverizer. The pulverized material in suspension in the gaseous carrier medium is carried upwardly to a classifier which operates to separate oversize material which returns by gravity towards the grinding zone, while the finer particles of material are discharged in suspension in the carrier medium from the classifier outlet through the housing pulverized material outlet to storage or a point of use.

The commercial value of pulverizers of the character described is dependent upon a number of factors including the original cost of the pulverizer and auxiliary equipment for a given output capacity, power consumption, fineness of output over the permissible load range, adaptability for operation with materials of different grindability, feed size, and moisture content, the extent of the operating load range, and the amount of the recirculating load. The size and power requirements of the fan or blower will depend upon the pulverizer static pressure differential and quantity handled.

With pulverizers of the character illustrated in said U. S. Patent No. 2,275,595, it has been found that the pulverizing capacity is limited by aeration and consequent fluidizing of the material in the grinding zone due to the direction of the gaseous carrier medium stream relative to the grinding zone, thus preventing the maximum utilization of the grinding capacity of the grinding parts, and the presence of a relatively dense slowly rotating annular mass of raw or partly pulverized particles at the outer side of the grinding zone believed to be due to accumulations in that area of oversize particles attempting to separate by gravity from the carrier gas stream, or rejected by the classifier and by-passing the grinding zone. The presence of this suspended dense annular mass of particles around the outside of the grinding zone results in a relatively high static pressure differential through the pulverizer as the mass fills substantially all of the space between the housing and the grinding elements, thus materially obstructing the flow path of the rising carrier gas stream. The mass acts like a filter bed for the rising suspended particles, with some of the suspended oversize particles being caught in the mass and lighter particles in the mass being picked up in the gas stream. The carrier gas flow through the

suspended mass is often non-uniform, as the gas stream will tend to follow the flow path of least resistance, resulting in an uneven peripheral distribution of the suspended particles to the classifier. The flow obstructing effect of the suspended mass of particles also causes a portion of the rising carrier gas stream to flow inwardly through the row of rolling grinding elements, thus opposing the outward flow of pulverized material and effecting aeration of the material in the grinding zone. The material thus fluidized is difficult to pulverize by the normal grinding action of the relatively moving rolling grinding elements and rings as it tends to flow out of the path of the cooperating grinding parts.

As disclosed and claimed in a prior application of W. C. King and L. L. Leach, Serial No. 124,754, filed November 1, 1949, now Patent Number 2,670,138, pulverizers of the character described can have their pulverized material output capacity increased and static pressure differential through the pulverizer decreased, without any decrease in fineness of output or increase in pulverizer size or cost, by an improved construction and arrangement of the non-rotary upper grinding ring, whereby the area available for re-entrance to the grinding zone of oversize material discharged from the grinding zone and picked up by the rising stream of carrier gas is substantially increased. For this purpose, the upper ring is made of vertically elongated cross-section with its major axis arranged substantially tangential to a ball radius at an angle of 45 degrees in the upper inner quadrant of the grinding balls and the ball contact area almost wholly confined to the upper inner ball quadrant and extending only a small arcuate distance beyond the ball vertical center line. For example, with 10½″ diameter balls, this distance was only ½″ in one installation. The outer face of the ring was arranged at an angle of approximately 30 degrees to the vertical. With this upper ring construction and arrangement, substantially the whole upper outer quadrant of the balls and the intervening spaces will be open to receive material dropping out of the carrier gas stream close to the point of initial pick-up or dropping downwardly through the space outside of the upper ring.

It has been found that in use such grinding rings have developed outward wear to such a degree that the grinding balls may not remain in their designed positions in the rotary lower ring race, and thereby cause an outage of the pulverizer, which in turn would cause an outage of the furnace serviced unless another fuel source was available. Any increase in the upper ring thickness to increase the ball contact area at the outer side of the ball row, i. e. the overhang, sufficient to eliminate this wear problem has been found to materially reduce the pulverizer capacity.

In accordance with the present invention, the upper non-rotary ring is provided with an increased overhang relative to the ball row without materially reducing the area available for back-feeding the race by forming the upper ring with a series of special lugs spaced in a particular manner along its outer side, the underside of the lugs being shaped to conform to the ball and form a continuation of the upper ring race profile. The lug faces are arranged at an inclination downward in the direction of pulverized rotation to utilize the swirling motion of the material passing the upper ring to induce a high rate of back-feeding in the gaps between the lugs. The lugs are circumferentially spaced on the outer side of the ring a distance preferably slightly less than the diameter of the grinding balls when new.

The various features of novelty which characterize my 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 ad-

vantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of my invention.

Of the drawings:

Fig. 1 is a sectional elevation of a pulverizer embodying the invention;

Fig. 2 is a perspective view of the grinding parts, and

Fig. 3 is an enlarged view of a portion of 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 lower section encloses the pulverizer gear drive which includes a horizontal pinion shaft 13 arranged to drive a vertical drive shaft 14 axially arranged in the housing. The drive shaft 14 extends upwardly through bearings arranged in a base plate 15 forming the top of the lower housing section 11. The housing section 10 is detachably secured to the base plate 15 and encloses the grinding parts of the pulverizer which comprises a drive yoke 17 of general conical form keyed on the upper part of the drive shaft 14 and an annular lower grinding ring 18 supported on and doweled to a flattened lower portion of the drive yoke. Part of the upper face of the lower grinding ring is shaped to form a circular track or race 19 for a row of rolling grinding elements 20, preferably balls of a wear-resistant ferrous alloy. The ball row supports a nonrotating upper grinding ring 21 having a circular ball track 22 formed in its lower face and constructed and arranged as hereinafter described.

At four symmetrically spaced points, arms 23 project radially outwardly from the upper ring and are provided with sockets 24 for receiving dual purpose springs 25. Each spring is formed of a length of spring steel bar stock bent to form a single complete coil turn having a large pitch diameter. The upper ends of the springs 25 fit into corresponding sockets 26 carried by vertical adjusting bolts 27. Each bolt 27 is supported in a sleeve bracket 28 on the housing top plate 29 by means of a nut 30 and retainer 31. The springs 25 provide a resilient compressive force for the application of a grinding pressure upon the grinding rings and balls as well as a resilient torsional force restraining the rotational and radial movement of the upper ring 21 relative to the axis of the lower ring 18. This dual purpose spring construction is disclosed and claimed in a copending application of L. L. Leach, Serial No. 783,248, filed October 31, 1947, now Patent No. 2,595,587.

The raw material to be pulverized is supplied by a regulable table feeder 35 through a housing opening 36 extending above the upper grinding ring and discharging down the inner side thereof to the upper inclined surface of the yoke 17 at the inner side of the ball row. The inclined surface of the yoke and the rotation thereof distributes the material circumferentially into the grinding zone. Due to the effect of centrifugal force the material flows outwardly into the ball race 19 where it is pulverized by the crushing action of the relatively moving grinding balls and rings and the attrition action of the particles on one another. The material is pulverized to various finenesses and discharges from the grinding zone at a high speed and tangentially to the periphery of the lower grinding ring, the velocity of discharge depending upon the rotational speed of the lower ring.

As shown in Figs. 1 and 3, the ball race 19 terminates at its inner side a short distance, e. g. ½", inwardly of the pitch circle of the ball row and the adjacent part 18a of the upper face of the lower grinding ring is cut away to a lower level to form a storage pocket which will tend to feed the material to be pulverized into the lower half of the ball race after the passage of each grinding ball and will result in both grinding and wear in this race area which promotes a wear direction more compatible with the direction of ball thrust.

The pulverized material is removed from the grinding area by a high velocity annular stream of a suitable gas-

eous carrier medium, preferably air, and when coal is being pulverized for combustion purposes, preferably the primary air supply used for combustion in the associated furnace. The air is supplied at a regulated temperature, e. g. 150–600° F., sufficient to eliminate substantially all of the surface moisture on the raw material undergoing pulverization. The air is preferably supplied under a superatmospheric pressure by a suitable forced draft fan (not shown) to an annular wind box 37 surrounding the lower part of the housing section 10. The carrier air passes through passages defined by equi-spaced obliquely arranged vanes 38 opening through the housing wall adjacent to the lower outer side of the lower grinding ring. The vanes 38 effect a swirling movement of the air stream in the same direction as the direction of lower ring rotation as it flows upwardly through the narrow annular passage between the lower grinding ring and housing.

The lower grinding ring is provided with an integral annular vertical ledge 40 spaced from the outer side of the ball row and extending vertically to a level sufficient to maintain the desired bed of material in the lower grinding race. For example, in one installation with balls 9¼" diameter, the top of the ledge was at the level of the ball centers. In operation, the ledge will act as a dam over which the pulverized material will flow under centrifugal force, the space within the ledge being normally filled with material at an angle corresponding to the angle of the free surface of the forced vortex of the pulverizer material.

The swirling stream of carrier air has its velocity increased to a value at a pulverizer level corresponding to the upper end of the ledge, at which value, e. g. 9000–12,000 ft./min., substantially all of the pulverized material flowing over the ledge will be picked up and carried upwardly in suspension. For this purpose, a narrow outwardly inclined throat at an angle of 60–70 degrees to the horizontal is defined by the outwardly flaring side of the ledge 40 and a parallel inverted frusto-conical plate 43, the stationary throat plate 43 being mounted for radial adjustment on the housing wall and extending inwardly and downwardly from the housing wall at the top level of the ledge substantially coextensive with the ledge 40. The upper surface of the ledge 40 is inwardly inclined and across which the pulverized material flows to the throat 42. In one embodiment, the throat was ¾" in width.

With the described throat construction and arrangement, the swirling air stream passes upwardly and on entering the throat 42 is directed outwardly at an acute angle to the housing wall, whereby the pulverized material flowing over and down the ledge 40 is swept up by the air stream adjacent the housing wall and carried upwardly in suspension. The larger or denser particles swept up tend to drop out of the upflowing air stream and the stream of air along the housing wall tends to direct such particles inwardly towards the grinding zone. Any small particles of dense unpulverized material, such as pyrites, will drop through the throat to the pulverizer space below the air entrance passages and be periodically discharged through a gate 50 into a compartment 51. The relative movement between the stationary plate 43 and rotating ledge 40 effectively prevents clogging of the throat 42.

The material-laden air stream swirls upwardly along the housing wall at the outer side of the upper grinding ring and laterally to a stationary classifier 60 of the type disclosed and claimed in an application of S. W. Culp, Serial No. 282,217, filed April 14, 1952. As disclosed in said application, the classifier is arranged to extend across the lower end of a turret 62, the top of which opens to the pulverized material outlets 63. The classifier has a casing 61 of circular cross-section supported in spaced relation from the top plate of the pulverizer, the annular opening therebetween being occupied by a circumferentially spaced series of angularly arranged separating blades

64 positioned between upper and lower annular plates **65** and **66** respectively. The upper plate **65** has a depending vertical flange **67** at its inner edge, as shown in Fig. 1. The lower end of the casing **61** surrounds the upper end of the drive yoke **17** which carries a series of curved blades **68** positioned in the space therebetween and which act to eject the oversize material separating out in the classifier and dropping to the lower portion of the casing **61**. The oversize material is thus returned to the inner side of the grinding ball row, mingling with the raw material therein from the feeder.

The oversize material so recirculated by the action of gravity and the classifier must be further pulverized before being fit for use. The recirculating load normally is many times the rate of discharge of the pulverized material from the pulverizer outlet, e. g. when pulverizing bituminous coal, 20–30:1. While such material dropping into the space at the inner side of the ball row readily reaches the grinding zone, the portion heretofore dropping on and outside the upper grinding ring was greatly delayed in again reaching the grinding zone. The reentrance of recirculated material to the grinding zone is greatly facilitated by a special construction and arrangement of the upper grinding ring. The body portion of the upper ring is of vertically elongated cross-section with its major axis arranged substantially tangential to a ball radius at an angle of 45 degrees in the upper inner quadrant of the grinding balls. The ring is so shaped that its ball contact area is almost wholly confined to the upper inner ball quadrant and extends only a small arcuate distance beyond the ball vertical center line. For example, with 9¼″ and 10½″ diameter balls this distance was only ½″. The upper end of the ring cross-section is continuously curved and slopes downwardly at its inner side for a major portion of its extent at an angle of approximately 45 degrees to the vertical with the remaining inner surface substantially vertical. The opposite face is arranged at an angle of approximately 30 degrees to the vertical. With this formation the geometrical center of the top ring will always be located at the inner side of the ball center line during the normal life of the parts. An upper ring construction having the desired strength, rigidity and life is thus provided. With this ring construction, substantially the whole upper outer quadrant of the balls and the intervening spaces are open to receive material dropping out of the air stream close to the point of initial pick-up, as indicated by the arrows in Fig. 3, or dropping downwardly through the space outside of the upper ring.

The described primary recirculation effect is enhanced in the present construction by the location of stationary deflectors or plows **69** projecting inwardly from the housing wall at symmetrically spaced locations adjacent the grinding zone. As shown in Fig. 3, each plow is sloped inwardly and upwardly in the direction of ring rotation at an angle of approximately 30 degrees from the vertical and approximately 45 degrees from the radial, so that it will extend at an angle across and immediately above the throat **42**. With this construction the larger oversize particles discharging from the grinding zone which cannot be lifted by the air stream tend to impact on the plows and be deflected back into the upper part of the ball row, avoiding any tendency towards the formation of a slowly rotating suspended mass outside of the grinding zone.

As shown in Fig. 1, a portion of the throat plate **43** is cut away at one segmental section to permit the installation of a counterweighted relief gate **70** of the same contour and pivoted on a shaft **71** to allow large pieces of unpulverizable material, such as tramp iron, to drop into the subjacent part of the pulverizer.

With the grinding balls and rings constructed and arranged as described, it has been found that in use such grinding rings have developed outward wear to such a degree that the grinding balls may tend to move radially

out of their illustrated positions in the lower rotary ring race. This would result not only in a loss in pulverizer capacity, but is likely to cause an outage of the pulverizer and possibly an outage of the equipment in which the pulverized material is used. Increasing the upper grinding ring lower end thickness to increase the ball contact area at the outer side of the ball row, i. e. the amount of overhang relative to the grinding balls, sufficient to eliminate this wear problem has been found to materially reduce the pulverizer capacity.

In accordance with the present invention, the upper grinding ring **21** is provided with an increased surface area overhanging and in contact with the ball row, without materially reducing the flow area available for back-feeding the grinding zone with material dropping out of the carrier gas stream. For this purpose the upper grinding ring **21** has a series of circumferentially spaced lugs **80** along its inclined outer side projecting outwardly therefrom. The lugs are preferably integrally formed on the ring and are downwardly flared in width and thickness, as shown in Figs. 2 and 3, from the junction of the outer side with the curved upper end of the ring. The underside **81** of the lugs is shaped to conform to the ball profile and to form a continuation of the grinding ring race **22**. The opposite faces **82**, **83** of the lugs are inclined downwardly in the direction of rotation of the lower grinding ring to utilize the swirling motion of the material passing the upper ring to induce a high rate of back-feeding of material into the gaps between the lugs. This action more than offsets the reduction in the flow area for back-feeding the grinding zone caused by the lugs. The lower ends of the lugs **80** are preferably spaced apart circumferentially an arcuate distance slightly less than the diameter of the grinding balls when new. With this arrangement, the ball-contacting area of the upper grinding ring is substantially increased without reducing the recirculation of the oversize material to the grinding zone above the horizontal centerline of the ball row. The increased ball-contacting area so located is sufficient to hold the grinding balls in their designed locations relative to the grinding ring races throughout the designed service life of the grinding rings.

Pulverizers of the construction described are characterized by greatly increased output with increased fineness and a decreased static pressure differential. The improved conditions in and adjacent to the grinding zone are attained by preventing carrier air flow directly into the ball row and thus avoiding aeration and consequent fluidizing of material at the time of pulverization; the maintenance of a bed of material on the grinding face of sufficient thickness to cause adequate pulverization on each passage of a particle through the grinding zone; the rapid scavenging of the undersize particles from the material leaving the grinding zone to prevent overgrinding and consequent power consumption; the recirculation of much of the oversize material to the grinding zone by the shortest practical route; the elimination of a dense mass of oversize material around the grinding zone; and the intimate mixing of the hot air and partially pulverized material at a point in the circulation path which insures proper drying of the material.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus covered by the claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features. In the claims, the word "air" is intended to cover generically any other gaseous carrier medium suitable for conveying pulverized material in the manner described.

I claim:

1. A pulverizer comprising a housing enclosing a rotary lower grinding ring, means for rotating said lower grinding ring, a circular row of grinding balls supported

on said lower grinding ring, a non-rotary upper grinding ring supported on said grinding balls, means for delivering material to be pulverized to the inner side of said row of grinding balls, means for directing an annular stream of air upwardly past the outer side of said grinding rings and row of grinding balls to sweep up pulverized material discharging therefrom, said upper grinding ring having a body portion cut away at its outer side to an extent sufficient to lay open a major portion of the upper outer quadrant of said grinding balls for the reception of recirculated material, and a series of lugs circumferentially spaced on and projecting outwardly from the outer side of said upper grinding ring body portion and having their ball-contacting undersides curved to correspond to the ball profile.

2. A pulverizer comprising a housing enclosing a rotary lower grinding ring, means for rotating said lower grinding ring, a circular row of grinding balls supported on said lower grinding ring, a non-rotary upper grinding ring supported on said grinding balls, means for delivering material to be pulverized to the inner side of said row of grinding balls, means for directing an annular stream of air upwardly past the outer side of said grinding rings and row of grinding balls to sweep up pulverized material discharging therefrom, said air flow directing means being constructed and arranged to define an annular throat inclined upwardly and outwardly to a point adjacent said housing so as to deflect the air stream away from said row of grinding balls, said upper grinding ring having a body portion cut away at its outer side to an extent sufficient to lay open substantially all of the upper outer quadrant of said grinding balls for the reception of recirculated material, and a series of lugs circumferentially spaced on and projecting outwardly from the outer side of said upper grinding ring body portion and having their ball-contacting undersides curved to correspond to the ball profile.

3. A pulverizer comprising a housing enclosing a rotary lower grinding ring, means for rotating said lower grinding ring, a circular row of grinding balls supported on said lower grinding ring, a non-rotary upper grinding ring having an arcuate race supported on said grinding balls, means for delivering material to be pulverized to the inner side of said row of grinding balls, means for directing an annular stream of air upwardly past the outer side of said grinding rings and row of grinding balls to sweep up pulverized material discharging therefrom, said upper grinding ring having a body portion cut away at its outer side to an extent sufficient to lay open a major portion of the upper outer quadrant of said grinding balls for the reception of recirculated material, and a series of lugs circumferentially spaced on and projecting outwardly from the outer side of said upper grinding ring body portion and having their undersides curved to form a continuation of said grinding ring race and opposite faces downwardly inclined in the direction of rotation of said lower grinding ring.

4. A pulverizer comprising a housing enclosing a rotary lower grinding ring, means for rotating said lower grinding ring, a circular row of grinding balls supported on said lower grinding ring, a non-rotary upper grinding ring having an arcuate race supported on said grinding balls, means for delivering material to be pulverized to the inner side of said row of grinding balls, means forming a peripheral ledge on and extending substantially above the ball-contacting surface of said lower grinding ring, means for directing an annular stream of air upwardly past the outer side of said grinding rings and row of grinding balls to sweep up pulverized material discharging therefrom, said air flow directing means

including an annular stationary throat plate constructed and arranged relative to said ledge-forming means to define therebetween an annular throat inclined upwardly and outwardly away from said row of grinding balls, said upper grinding ring having a body portion cut away at its outer side to an extent sufficient to lay open a major portion of the upper outer quadrant of said grinding balls for the reception of recirculated material, and a series of lugs circumferentially spaced on and projecting outwardly from the outer side of said upper grinding ring body portion and having their undersides curved to form a continuation of said grinding ring race.

5. A pulverizer comprising a housing enclosing a lower rotary grinding ring having an arcuate race formed on its upper surface, means for rotating said lower grinding ring, a circular row of grinding balls supported on said lower grinding ring race, a non-rotary upper grinding ring supported on said grinding balls, means for delivering material to be pulverized to the inner side of said row of grinding balls, means forming a peripheral ledge on and extending above the upper surface of said lower grinding ring, means for directing an annular stream of air upwardly past the outer side of said grinding rings and row of grinding balls to sweep up pulverized material discharging therefrom, said lower grinding ring race having its inner edge terminating adjacent the vertical center line of said ball row, and the upper surface of the inner portion of said lower grinding ring adjacent the vertical centerline of said race being cut away below the level of said race to form a material storage pocket.

6. A pulverizer upper grinding ring having an arcuate race adapted to be supported on a circular row of grinding balls, said upper grinding ring having a body portion cut away at its outer side from the outer edge of said arcuate race at an acute angle less than 45° to the vertical to an extent sufficient to expose a major portion of the upper outer quadrant of said grinding balls when positioned thereon and a series of lugs circumferentially spaced on and projecting outwardly from the outer side of said upper grinding ring body portion and having their undersides curved to form a continuation of said grinding ring race whereby the underside of said lugs contact the upper outer quadrant of said grinding balls.

7. A pulverizer non-rotary upper grinding ring having an arcuate race adapted to be supported on a circular row of grinding balls, said upper grinding ring having a body portion cut away at its outer side to an extent sufficient to expose substantially all of the upper outer quadrant of said grinding balls and having its major cross-sectional axis outwardly inclined and its geometrical center at the inner side of the vertical center line of said grinding balls when positioned thereon, and a series of lugs circumferentially spaced on and projecting outwardly from the outer side of said body portion and having their undersides curved to form a continuation of said grinding ring race whereby the underside of said lugs contact the upper outer quadrant of said grinding balls and opposite faces of said lugs being downwardly inclined in the same direction.

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