Aug. 27, 1935. E. G. BAILEY ET AL 2,012,802

PULVERIZING MILL

Filed Nov. 16, 1931 3 Sheets-Sheet 1

Fig. 1

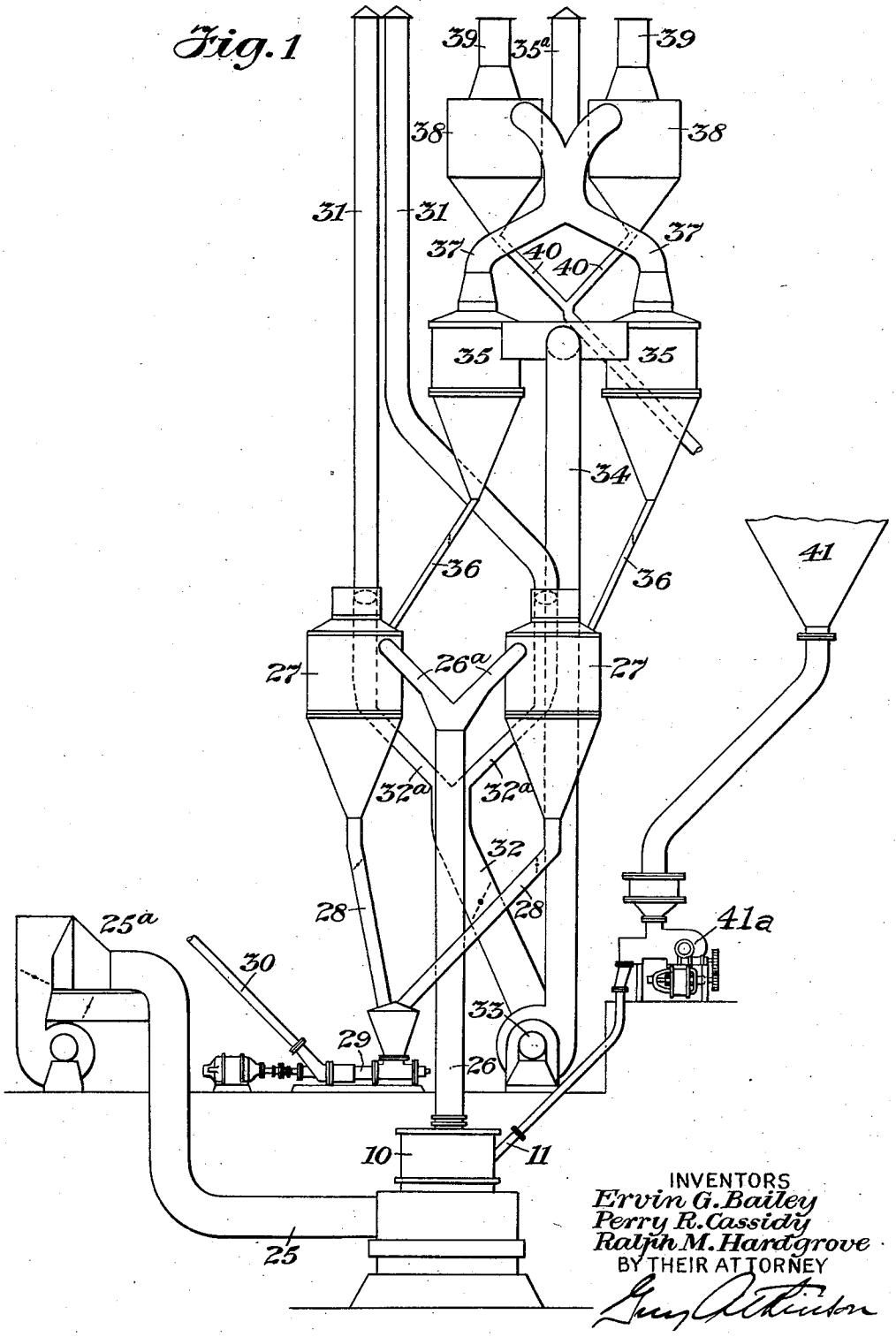

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Fig. 2

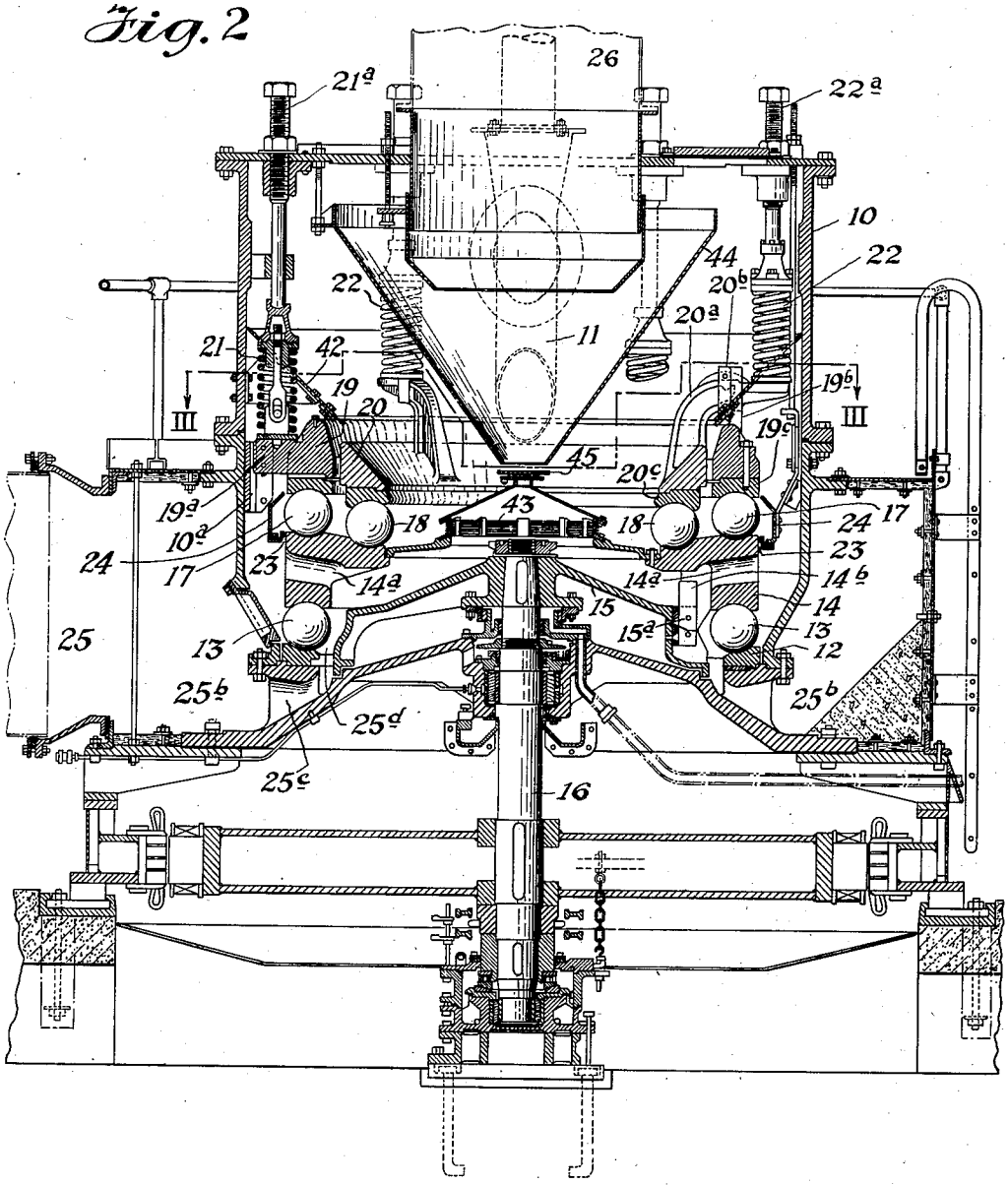

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Fig. 3

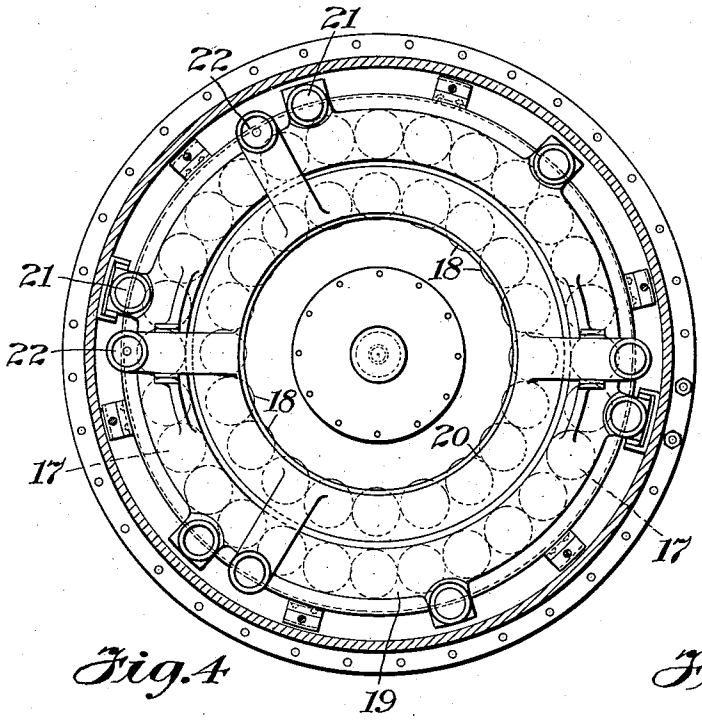


Fig. 4

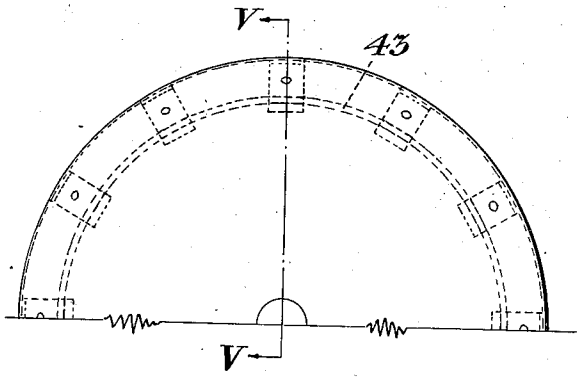
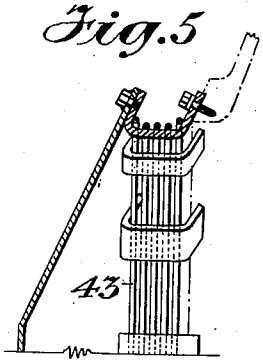


Fig. 5



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UNITED STATES PATENT OFFICE

2,012,802

PULVERIZING MILL

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Application November 16, 1931, Serial No. 575,454

15 Claims. (Cl. 83—45)

Our invention relates to pulverizing mills and more particularly pulverizing mills in which pulverization is accomplished by balls operating between grinding rings.

One object of the invention is the provision of a pulverizing mill which will function more effectively than those now in use. Another object is the construction of such a mill in a form which will permit a greater number of successive pulverizations of the material upon which it acts. A further object is the provision of a pulverizing mill which will have a greater capacity than those now in use. Still a further object is the provision of such a mill which will provide more effective separation of fines than has heretofore been possible. Other objects will appear upon consideration of the present specification.

One form of the invention is illustrated in the accompanying drawings wherein—

Figure 1 is a more or less diagrammatic view of the mill and its feed and delivery connections,

Fig. 2 is a vertical section through a mill constructed in accordance with the invention,

Fig. 3 is a horizontal section on the line III—III of Fig. 2, and

Figs. 4 and 5 are detailed views of the bar screen illustrated in Fig. 2.

In the drawings there is shown a mill casing 10 having a delivery chute 11 projecting through it. In the lower part of the casing 10 is positioned a stationary lower grinding ring 12 upon which a row of grinding balls 13 rests. An intermediate grinding ring 14 is driven by a yoke 15 and has a lower race thereon which rests on top of the lower balls 13. The intermediate grinding ring is rotatable, the yoke 15 coacting therewith and being carried on a vertical shaft 16 to which it is keyed. The intermediate ring 14 is free to move in an upward direction subject to the resistance imposed by the compression springs 22, and therefore a floating drive is provided between the yoke 15 and the ring 14. Such a drive is provided by two bosses 15^a and 14^b, one of which, 15^a, is attached to the yoke 15 and other 14^b is attached to the driven ring 14. These bosses bear against each other but are free to move relative to each other in a vertical direction. Provision is made for rotating the shaft 16 in any known or convenient manner, but this rotating means forms no part of the present invention. The intermediate grinding ring 14 has a double upper race therein in which two rows of grinding balls 17—18 are positioned. Thus, there is provided an outer row or ring of grinding balls 17 and an inner row or ring of grinding balls 18, each row or ring being supported in an upper race on the intermediate grinding ring 14. The outer row of grinding balls is preferably carried at a slightly greater elevation than the inner row for a purpose which will later be apparent.

Two upper grinding rings 19 and 20 are provided, the outer grinding ring 19 resting upon the outer row of grinding balls 17 and the inner grinding ring 20 resting upon the inner row of grinding balls 18. Thus, the two rows of upper grinding balls are positioned between the upper grinding rings and the upper races of the intermediate grinding ring 14.

The faces 19^c and 20^c which are subject to wear are made in separate rings so that they can be renewed without sacrificing the rings 19 and 20 which are more expensive castings.

The springs 21 and 22 are arranged in a single circular row, offset arm extensions 20^a of the ring 20 being carried outwardly to provide the proper offset to transmit the compression force from spring 22 to ring 20. Although the rings 19 and 20 are free to move independently in a vertical direction under restraint of compression means 21 and 22, they are held against the tendency to rotate. This is accomplished by holding an extension 19^a to the outer ring 19 between lugs 10^a attached to the outer casing of the mill. The extension can move vertically between the flat sides of the lugs which are provided with removable and renewable wearing plates. The inner ring 20 is in turn held against rotation by means of a bearing between wearing plates 20^b attached to one of the spring arms 20^a and coacting wearing plates 19^b attached to brackets on the outer ring 19.

Means are provided for exerting a downward pressure upon each of the upper grinding rings in order to permit grinding between the rings and the three sets of grinding balls. As illustrated in the drawings, spring means 21 are provided for exerting such pressure upon the outer upper grinding ring 19 and thus upon the outer upper row of grinding balls 17; and separate spring means 22 are provided for exerting downward pressure upon the inner grinding ring 20 and thus upon the inner upper row of grinding balls 18.

The springs 21 and 22 are provided with independent adjusting screws 21^a and 22^a so that each ring can be subjected to the proper ratio of grinding pressure which is determined by the characteristics of the material being pulverized.

It will be apparent that each of the upper

grinding rings exerts a pressure through the row of balls beneath it to the intermediate grinding ring 14 and thence to the lower row of grinding balls 13 and the lower grinding ring 12. It will be further apparent that a ball in either the inner or the outer row of upper grinding balls may be raised without causing the upper grinding ring with which it is not in contact to be raised. This permits balls in one upper row to be lifted without releasing pressure on the other upper row of balls, and is an advantage where hard material passes beneath the upper grinding balls.

In operation the material to be pulverized enters the casing 10 through the feed chute 11 and falls inside the inner row of upper grinding balls 18. A small quantity of this material collects in the annular space inside of these grinding balls and is projected outwardly by centrifugal force to the inner race of the intermediate grinding ring 14 where it is given a preliminary pulverization by the inner row of upper grinding balls 18. The material is then impelled outwardly aided by centrifugal force and passes into the outer upper race of the intermediate grinding ring where it is given a second pulverization by the outer row of grinding balls 17. Positioning the outer row of grinding balls slightly above the inner row results in a tendency for the finer material to pass to this outer row and receive the second pulverization, whereas the coarser, heavier particles will tend to remain beneath the inner row of grinding balls 18. From the foregoing statement it will be apparent that raising the outer upper race will retard the outward flow of material, and lowering the outer upper race will accelerate the flow of material. Thus, where a mill is designed for use in connection with difficultly pulverized material, the outer race will be elevated, and where the mill is designed for use with easily pulverized material the flow of material may be accelerated by reducing, omitting or reversing this elevation of the outer race.

Fine material which has received the second pulverization beneath the outer row of grinding balls 17 passes outwardly under the influence of centrifugal force and moves downwardly through a small annular passageway 23 formed by an adjustable annular baffle 24 surrounding the intermediate grinding race. Thence the material moves downwardly and the coarser material which is too coarse to be picked up by the upward current of air which will be hereinafter referred to, passes to the bottom of the annular space outside of the balls 13 and then flows inwardly beneath the lower rows of balls 13 upon the lower grinding ring 12. In passing between the balls 13 and ring 12, the remaining material receives its final pulverization.

In order to maintain the efficiency of pulverization at its best, it is very important that the finely pulverized material be quickly swept out of the pulverizing zone immediately upon being reduced to proper fineness, and this is accomplished by the air flow through and about the grinding zone, as hereinafter described. If the finely pulverized material is not removed it will act as a cushion between the grinding surfaces and reduce the efficiency of the pulverizing or grinding action.

In the arrangement of mill shown in Figure 1, the exhauster or fan 33 induces a suction through its connections 32, 27, and 26 to the top of the mill casing 10. This suction induces an air flow through the mill from air connection 25. With this arrangement the mill is a so-called suction mill, but it may also be arranged as a pressure mill by placing a fan or blower in the connection 25 and forcing the air or other gas through the mill under pressure.

A pipe 25 is connected to an annular air chamber 25^b which distributes the air evenly to a plurality of ports 25^c formed in the support for the grinding ring 12. After passing inwardly through the ports 25^c toward the axis of the mill, the air is directed upward by the inner curved bottom portion of the support casting and is then deflected into proximity to the inner sides of the row of balls 13 by the lower skirt of the rotary yoke 15. The annular opening 25^d between the ring 12 and the skirt of the yoke 15 is of limited cross-sectional area so that the air velocity will be sufficient to pick up both pulverized and unpulverized material of proper weight and carry it back to the grinding zone or through to the classifying section of the mill.

From 25^d the air stream divides, a relatively small portion of the air passing between the balls 13 to the annular space B between the balls and the casing and then upward to the outside of baffle 24, while the remaining portion passes inside of the lower row of balls. This second portion of the air then divides and part flows through the ports 14^a to the annular space B external of the ring 14 where it joins the air which has passed outwardly through the balls 13. The rest of the air passes inwardly and then upwardly and is discharged through a bar screen 43 shown in detail in Fig. 4. In passing through the row of balls 13 and outwardly of the same balls, the current of air picks up pulverized material, which if pulverized to the proper fineness, is carried by the air to the outlet pipe 26.

Located above the annular space B and also above the baffle 24 and upper rings 19, a conical baffle ring 42 is located. This baffle ring extends from the external casing 10 downward to the inside and at approximately the elevation of the top of the upper ring 19. It is fitted quite closely about the springs 21 and 22 so that the direct upward flow of air can be deflected downward toward the grinding zone in order to throw out particles of material which have not been reduced to the proper fineness. The inner and lower portion of this baffle ring may be made adjustable to regulate the annular opening between it and the ring 19.

As the discharge through the gap 23 contains considerable material which has reached the degree of fineness which will allow it to be carried by the air stream, this fiine material as well as similarly pulverized material which is discharged over the top baffle 24 is carried by the air stream in its passage upward external of the ring 19 and between the ring 19 and the baffle ring 42. From the lower edge of the baffle 42 the air flows upward in a large unrestricted space in the upper portion of the mill housing and the reduced velocity allows the coarser particles to drop out of the air current. These particles are returned to the upper grinding zone and may fall to the inner side of the ring 20 and thereby be returned to the pulverizing action of the balls 18, or a part of such material may be dropped through the annular space between the rings 19 and 20, thereby being returned directly to the pulverizing action of balls 17.

That portion of the air which flows upward through the grid screen 43, also carries some pul-

verized material. Any coarse particles which may fall out of this stream drop on the downwardly sloping top of the yoke 15 and are thereby thrown outward by centrifugal force to the lower row of balls 13. The air issuing through the bar screen 43 flows upward to the outside of the cone 44 along with the air passing under baffle 42, but in so doing it passes through the raw coal being fed to the inside of the balls 18, the material which returns from the bottom of the cone 44 and in close proximity to whatever material may remain on the inclined plate to the inside of the balls 18. In so doing, this air current acts to pick up fines and carry them upward to the classifier section.

The upwardly passing stream of air which has collected the fines in the mill passes to the top of the casing 10 and thence downwardly into a conical shell 44, which is the shell of a separator. Changing its direction inside of the conical shell 44 the air precipitates the heavier particles which have been carried and passes upwardly through the pipe 26 and to the separators and other apparatus above, as will be hereinafter described.

The inwardly extending conically shaped flange at the lower portion of 26 provides an arrangement whereby the stream of material-laden air can be directed downward toward the bottom portion of the cone 44 without causing undue restriction in the air flow with consequent high velocities, pressure drop and inefficient separation of material. Its conical portion is substantially parallel to the cone 44 and it is provided with adjustable hangers so that the annular opening between the two cone portions can be adjusted as to size to regulate the degree of separation.

The air enters the pulverizer through a pipe 25 having first been heated to proper degree in an apparatus indicated diagrammatically by the numeral 25a in Figure 1. The air then passes upwardly through the mill and out through an outlet pipe 26. On its way the air picks up coal which has been sufficiently pulverized to be carried by it in suspension.

Air which has passed through the pulverizer moves upwardly through a pipe 26 to a pair of cyclone type separators 27 (see Figure 1) and the pulverized material is here separated and is delivered through pipes 28 to a transport apparatus 29 here illustrated as the well known Fuller Kinyon pump, whence it is conveyed through a pipe 30 to a storage tank or bin (not shown).

The separators 27 have suitably valved explosion vent pipes 31—31 to the external atmosphere. Vent connections 32a—32a carry the air and residual fine material which was not removed by the cyclone separators 27, to a duct 32 which in turn carries this material to a centrifugal suction fan 33 which impels the air and residual material through a tube 34 to a second pair of cyclone type separators 35—35. The separators 35—35 precipitate the majority of the residual dust from the air and the former passes downwardly through pipes 36—36 discharging to the two separators 27—27 which have formerly been described. The separators 35—35 are provided with suitable valve explosion vents 35a. The air to be discharged to the atmosphere passes upwardly from the two separators 35—35 through tubes 37—37 to a pair of gas washers 38—38 which may be wet or dry washers and which separate all the remaining dust and fine material from the air so that the latter may be passed to the atmosphere through tubes 39—39.

The dust removed from the air in the washers 38—38 is collected and carried away in known manner, as illustrated diagrammatically by the tubes 40—40.

The feed apparatus to the pulverizing mill is illustrated in Figure 1 by a hopper 41 and appropriate connections to the delivery chute 11. These connections may include a drag feeder 41a which regulates the rate of feed.

While in accordance with the provisions of the statutes we have illustrated and described herein the best form of our invention known to us, those skilled in the art will understand that changes may be made in the form of the apparatus and character of the carrier medium disclosed without departing from the spirit of the invention covered by our claims, and that certain features of our invention may sometimes be used without a corresponding use of other features. In our claims, the word "air" is used generically to cover any gaseous carrier medium suitable for removing pulverized material in the manner described.

With this understanding, therefore, we claim:

1. In a pulverizing mill, a lower grinding ring, two upper grinding rings, an intermediate grinding ring having a single lower race and a double upper race, and means for passing air between said lower grinding ring and said intermediate grinding ring outwardly and upwardly of said grinding rings, in combination with means for passing air upwardly and inwardly of the grinding rings,

2. In a pulverizing mill, a lower grinding ring, two upper grinding rings, an intermediate grinding ring having a single lower race and a double upper race, and means for passing air between said lower grinding ring and said intermediate grinding ring outwardly and upwardly of said grinding rings, in combination with means for passing air upwardly and inwardly of the grinding rings, and a baffle above said upper grinding rings for directing inward the air stream passing outwardly of the grinding rings.

3. An air-swept pulverizer comprising means forming upper and lower vertically spaced grinding stages, means for supplying material to be pulverized successively to said upper and lower grinding stages, means causing a stream of scavenging air to pass through the stream of material during its passage from said upper stage to said lower stage, and means causing a second stream of scavenging air to pass in contact with the stream of material before the material enters said upper stage.

4. An air-swept pulverizer comprising means forming upper and lower vertically spaced grinding stages, means for supplying material to be pulverized successively to said upper and lower grinding stages, means causing a stream of carrier air to sweep up pulverized material leaving said lower stage, means causing a portion of said stream of air to subsequently pass through the stream of material passing from said upper stage to said lower stage, and means causing a second portion of said stream of air to subsequently pass in contact with the stream of material before the material enters said upper stage.

5. An air-swept pulverizer comprising a casing, means forming upper and lower vertically spaced grinding stages in said casing, means for supplying material to be pulverized successively to said upper and lower grinding stages, means causing a stream of heated carrier air to sweep up pulverized material leaving said lower stage, and means causing a portion of said air stream to subsequently pass upwardly out of contact

with the material passing between said grinding stages and in contact with the material entering said upper grinding stage.

6. An air-swept pulverizer comprising a casing having an inlet for material to be ground and an outlet for ground material in the upper part thereof, a plurality of vertically spaced grinding rings in said casing, upper and lower circular rows of rolling grinding elements positioned between different pairs of grinding rings and cooperating therewith to form a plurality of grinding stages receiving material to be ground at one side of said row of elements and discharging ground material at the other side, means causing a stream of air to pass upwardly through said casing adjacent to and mainly past the discharge side of said lower row of elements, means causing a portion of said air stream to subsequently pass through the stream of material passing to said lower row of elements and a second portion to pass upwardly through the stream of material passing to said upper row of elements.

7. An air-swept pulverizer comprising a casing having an inlet for material to be ground and an outlet for ground material in the upper part thereof, a plurality of vertically spaced grinding rings in said casing, upper and lower circular rows of rolling grinding elements positioned between different pairs of grinding rings and cooperating therewith to form a plurality of vertically spaced grinding stages receiving material to be ground at one side of said row of elements and discharging ground material at the other side, means causing an annular stream of air to pass upwardly through said casing adjacent to and mainly past the discharge side of said lower row of elements, means causing a portion of said air stream to subsequently pass upwardly through the stream of material passing to said lower row of elements and a second portion to pass upwardly past the inlet side of said upper row of elements and through the stream of material passing thereto.

8. An air-swept pulverizer comprising a casing enclosing an upper row of rolling grinding elements having an outward flow of material therethrough, an intermediate grinding ring supporting said upper row of elements, an upper grinding ring supported on said upper row of elements, a material feed opening in the upper portion of said casing arranged to deliver material to the inner side of said upper row of elements, a lower grinding ring, a lower row of rolling grinding elements positioned between said intermediate and lower grinding rings and receiving material by gravity from said upper row of elements and having an inward flow of material therethrough, and means causing a stream of air to pass upwardly past the inner side of said lower row of elements and to subsequently divide into a plurality of streams, one of which passes upwardly through the stream of material descending to said lower row of elements, and another of which passes upwardly at the inner side of said upper row of elements.

9. An air-swept pulverizer comprising a casing enclosing an upper row of rolling grinding elements having an outward flow of material therethrough, a rotary intermediate grinding ring supporting said upper row of elements, a non-rotary upper grinding ring supported on said upper row of elements, a material feed opening in the upper portion of said casing arranged to deliver material to be pulverized to the inner side of said upper row of elements, a lower non-rotary grinding ring, a lower row of rolling grinding elements positioned between said intermediate and lower grinding rings and receiving material by gravity from said upper row of elements and having an inward flow of material therethrough, and means causing a stream of air to pass upwardly past the inner side of said lower row of elements and to subsequently divide into a plurality of streams, one of which passes upwardly through the stream of material descending to said lower row of elements, and another of which passes upwardly in proximity to the inner side of said upper row of elements.

10. An air-swept pulverizer comprising a casing enclosing an upper row of rolling grinding elements having an outward flow of material therethrough, an intermediate grinding ring supporting said upper row of elements, an upper grinding ring supported on said upper row of elements, a material feed opening in the upper portion of said casing arranged to deliver material to the inner side of said upper row of elements, a lower grinding ring, a lower row of rolling grinding elements positioned between said intermediate and lower grinding rings and receiving material by gravity from said upper row of elements and having an inward flow of material therethrough, a series of ports extending between the inner and outer sides of said intermediate ring, and means causing a stream of air to pass upwardly past the inner side of said lower row of elements and to subsequently divide into a plurality of streams, one of which passes outwardly through the ports in said intermediate ring, and another of which passes upwardly in proximity to the inner side of said upper row of elements.

11. An air-swept pulverizer comprising a casing enclosing an upper row of rolling grinding elements having an outward flow of material therethrough, a rotary intermediate grinding ring supporting said upper row of elements, a non-rotary upper grinding ring supported on said upper row of elements, a material feed opening in the upper portion of said casing arranged to deliver material to the inner side of said upper row of elements, a lower non-rotary grinding ring, a lower row of rolling grinding elements positioned between said intermediate and lower grinding rings and receiving material by gravity from said upper rows of elements and having an inward flow of material therethrough, means causing a stream of air to pass upwardly past the inner side of said lower row of elements and to subsequently divide into a plurality of streams, one of which passes upwardly through the stream of material descending to said lower row of elements, and another of which passes upwardly in proximity to the inner side of said upper row of elements, and a screen arranged in the path of said last mentioned stream prior to said upper row of elements.

12. An air-swept pulverizer comprising a casing enclosing inner and outer upper concentric rows of rolling grinding elements having an outward flow of material therethrough, a rotary intermediate grinding ring supporting said inner and outer rows of elements, inner and outer concentric non-rotary upper grinding rings respectively supported on said inner and outer rows of elements, a material feed opening in the upper portion of said casing arranged to deliver material to the inner side of said upper inner row of elements, a lower non-rotary grinding ring, a lower row of rolling grinding elements positioned be-

tween said intermediate and lower grinding rings and receiving material by gravity from said upper outer row of elements and having an inward flow of material therethrough, and means causing a stream of air to pass upwardly past the inner side of said lower row of elements and to subsequently divide into a plurality of streams, one of which passes upwardly through the stream of material descending to said lower row of elements, and another of which passes upwardly in proximity to the inner side of said upper inner row of elements.

13. An air-swept pulverizer comprising a casing enclosing inner and outer upper concentric rows of rolling grinding elements having an outward flow of material therethrough, a rotary intermediate grinding ring supporting said inner and outer rows of elements, inner and outer concentric radially spaced non-rotary upper grinding rings respectively supported on said inner and outer rows of elements, a material feed opening in the upper portion of said casing arranged to deliver material to the inner side of said upper inner row of elements, a lower non-rotary grinding ring, a lower row of rolling grinding elements positioned between said intermediate and lower grinding rings and receiving material by gravity from said upper outer row of elements and having an inward flow of material therethrough, means causing a stream of air to pass upwardly past the inner side of said lower row of elements and to subsequently divide into a plurality of streams, one of which passes upwardly through the stream of material descending to said lower row of elements, and another of which passes upwardly in proximity to the inner side of said upper inner row of elements, and a screen mounted on said intermediate ring and arranged in the path of said last mentioned stream prior to said upper inner row of elements.

14. An air-swept pulverizer comprising a casing enclosing a lower rotary grinding ring, inner and outer concentric rows of rolling grinding elements supported on said lower grinding ring and having an outward flow of material therethrough, inner and outer upper spaced concentric grinding rings mounted on said inner and outer rows of elements respectively, means causing a stream of air to pass upwardly and sweep up material leaving said outer row of elements, and means in the path of the material-laden air causing coarse particles to be returned directly to said outer row of elements.

15. An air-swept pulverizer comprising a casing enclosing a lower rotary grinding ring, inner and outer concentric rows of rolling grinding elements supported on said lower grinding ring and having an outward flow of material therethrough, inner and outer upper spaced concentric grinding rings mounted on said inner and outer rows of elements respectively, means causing a stream of air to pass upwardly at the outer side of said outer row of elements and sweep up material leaving said outer row of elements, and a baffle above said rows of elements arranged to direct the material-laden air inwardly and downwardly and cause coarse particles to be returned directly to said inner and outer rows of elements respectively.

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