April 29, 1941. W. I. SALLEE 2,240,269

PULVERIZING MILL

Original Filed June 23, 1934 3 Sheets-Sheet 1

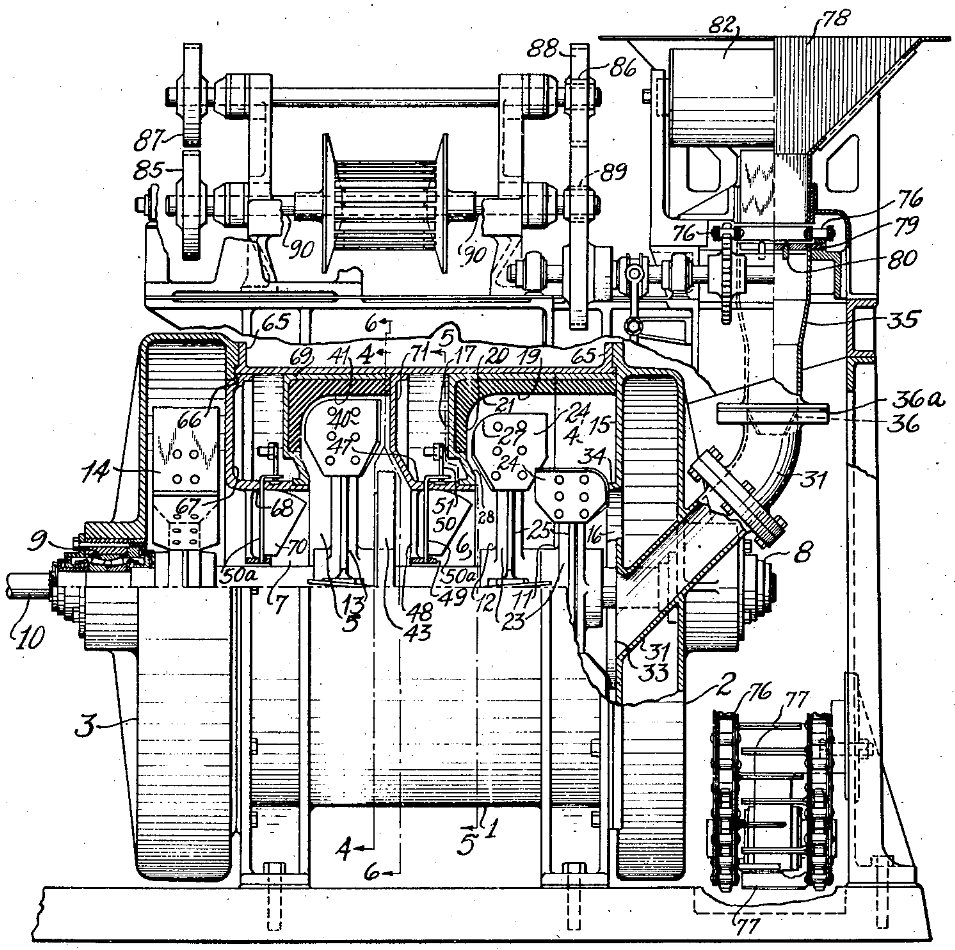

Fig. 1

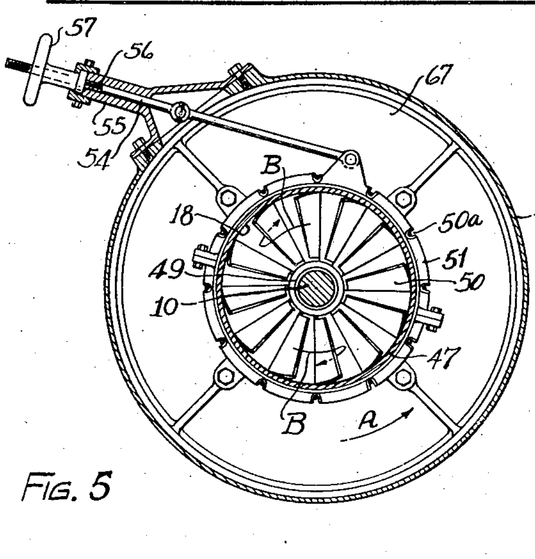

Fig. 5

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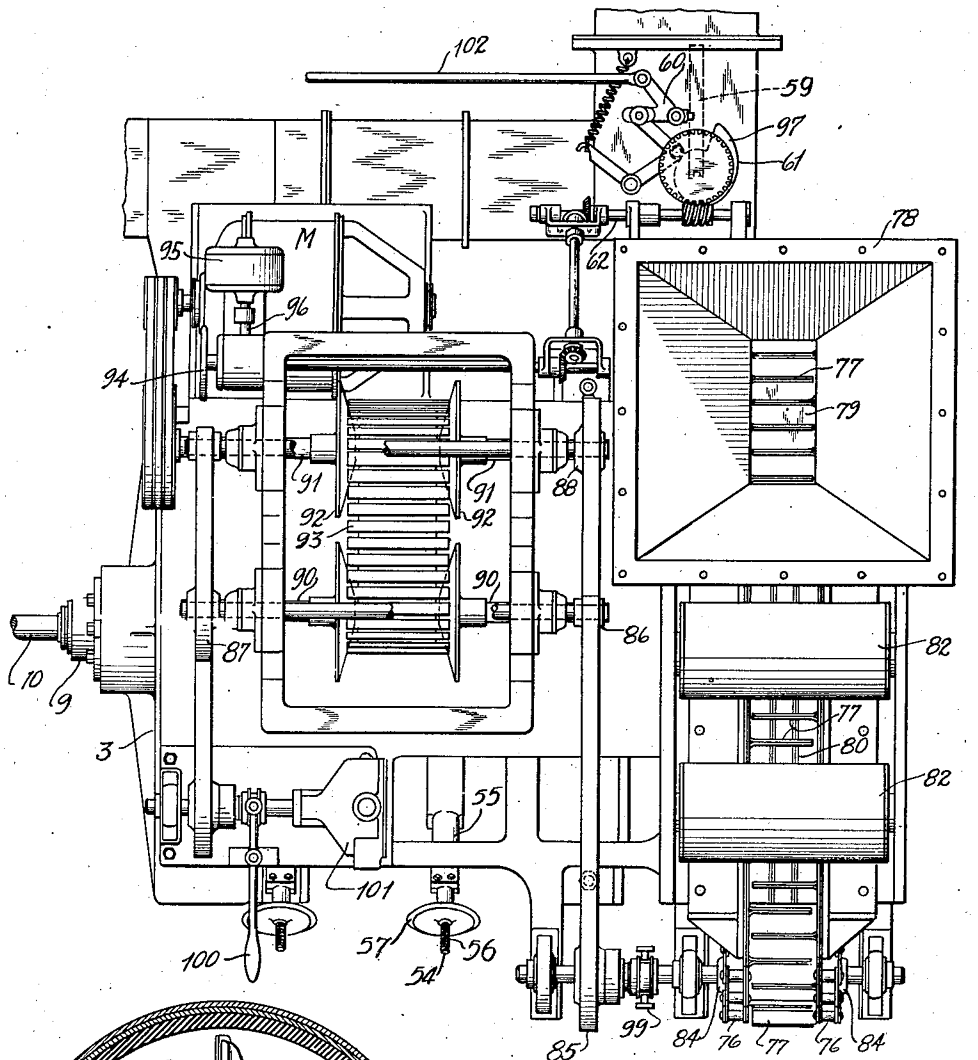

FIG. 2

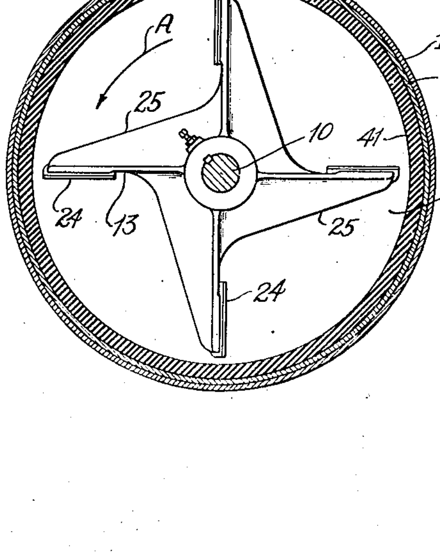

FIG. 4

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Original Filed June 23, 1934 3 Sheets-Sheet 3

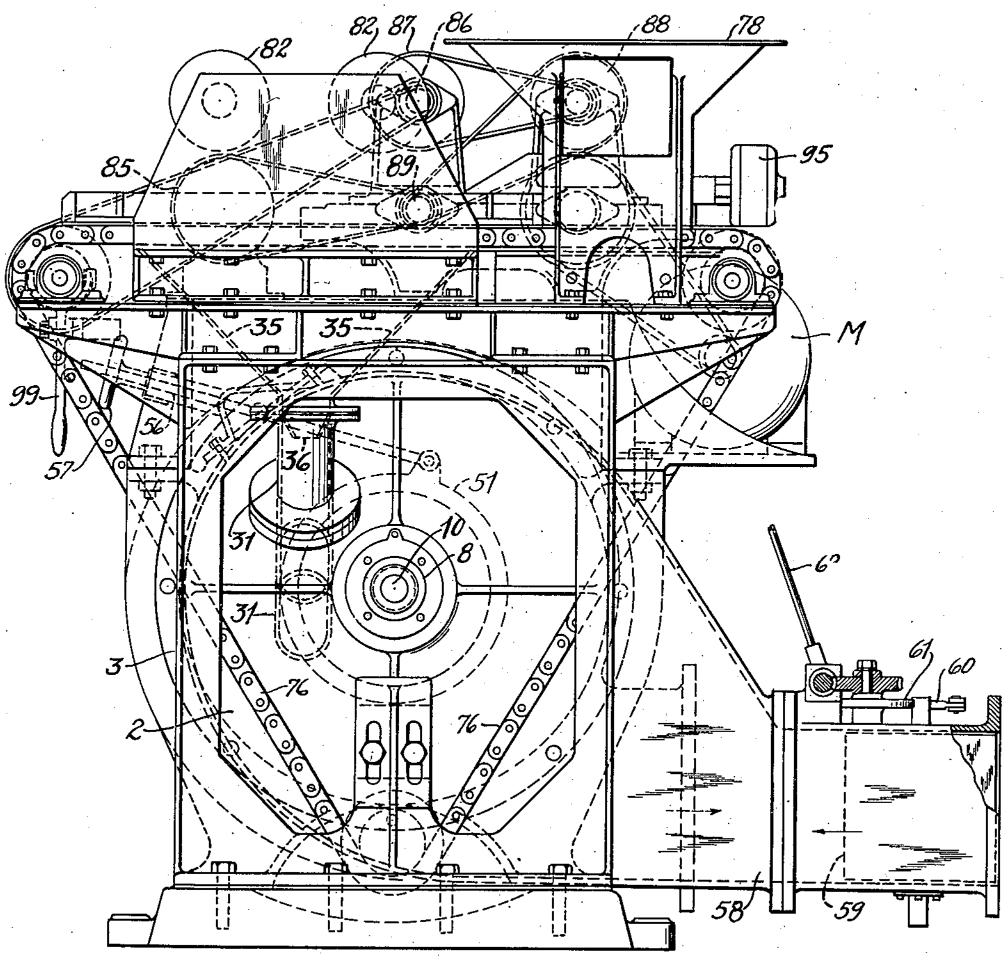

FIG. 3

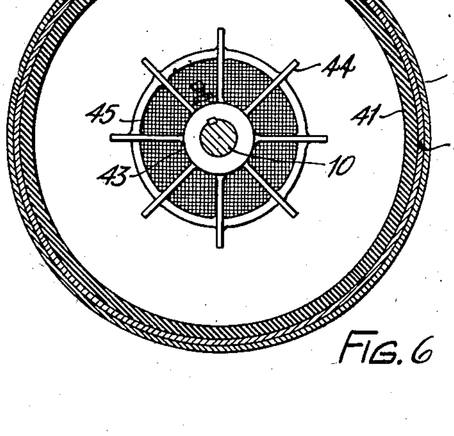

FIG. 6

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2,240,269

PULVERIZING MILL

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Application June 23, 1934, Serial No. 732,125
Renewed April 22, 1940

8 Claims. (Cl. 83—11)

This invention relates to attrition pulverizing mills for grinding and pulverizing coal, silica, sands, pigments and numerous other materials.

The principal object of the present invention is to pulverize such materials to predetermined and accurate fineness more efficiently and to maintain the desired degree of fineness at various rates of feed of the material into the mill.

Correlative objects are to stir and aerate the bed of attrition thoroughly and continuously in a manner such that the particles are removed from the bed substantially concurrently with their reduction to the desired fineness whereby the mutual attrition of the coarser particles is unimpeded and rendered more effective and rapid, the power requirements for grinding reduced, and the relative capacity of the mill increased.

Other objects are to control the currents of air and passage of materials through the mill so as to effect separation of the pulverized material by air flotation and to reduce greatly the tendency of the air to produce currents of such velocity and direction as to remove coarser material from the mill and further to mechanically retain coarser particles in the grinding chamber until ground to the proper degree of fineness.

A more specific but equally important object is to provide an attrition mill in which the air supplied to the mill is admitted separately from the material and the two are disassociated until actually admitted to the grinding chamber whereby the proportions of air and material, and consequently the uniformity of grind, may be more accurately controlled for different rates of grinding.

Other specific objects are to provide a mill having a plurality of grinding compartments with means for accurately controlling the currents of air through each independently, and having incorporated therein a centrifugal separator for separating the coarser particles from the finer and permitting only the finer to pass through the mill.

Another object is to provide a mill in which the component parts can be readily assembled and disassembled for replacement and repair and which, when assembled, are protected against undue wear.

Other objects and advantages will become apparent from the following specification wherein reference is made to the drawings in which:

Fig. 1 is a side elevation of a pulvertizing mill and feed mechanism embodying the principles of the present invention, part thereof being shown in section for clearness in illustration;

Fig. 2 is a top plan view of the mill and feed mechanism illustrated in Fig. 1;

Fig. 3 is an end elevation of the mill and feed mechanism;

Figs. 4, 5, and 6 are sectional views of the mill taken on planes indicated by the lines 4—4, 5—5, and 6—6 respectively of Fig. 1, parts remote from the section plane being omitted for clearness in illustration.

Referring to Figs. 1 to 3, the mill comprises generally a cylindrical casing 1 having at one end an air inlet housing 2 and at the opposite end an exhaust fan housing 3. Within the casing 1 is a primary grinding or pulverizing chamber 4 and a secondary grinding chamber 5. The air inlet housing 2 communicates with the primary chamber 4 which, in turn, communicates with the secondary chamber 5, the latter compartment communicating with the exhaust fan housing 3. Intermediate the chambers 4 and 5 is a discharge passage 6 in which are mounted adjustable air control directional vanes or damper means for controlling the effective size of the air discharge passage. Correspondingly, between the secondary chamber 5 and the exhaust fan housing 3 is a discharge passage 7 in which are mounted a set of vanes or damper means which are adjustable independently of the vanes in the passage 6 and control the effective size of the passage 7.

The housings 2 and 3 are preferably coaxial with the casing 1 and are provided with suitable sets of dust proof bearings 8 and 9 respectively, in which the main driving shaft 10 of the mill is rotatably mounted. Carried on the shaft 10, within the grinding chamber 4, are a plurality of rotors 11 and 12, shown in Fig. 1 as two in number for purposes of illustration, these rotors being secured to the shaft for rotation therewith. A similar rotor 13 is likewise fixedly secured to the shaft 10 and is disposed within the secondary grinding chamber 5. Mounted on the shaft in the exhaust fan housing is a suitable exhaust fan 14 operable to maintain a flow of air from the inlet housing 1 through the mill and to discharge the material laden air to its points of application.

Referring in greater detail to the specific elements of the mill, the inner end wall of the air inlet housing 1 is in the form of an integral annular baffle 15, having a central discharge opening 16 through which air introduced into the inlet housing may pass to the primary grinding chamber axially and centrally of the rotor 11. The baffle 15 of the inlet housing likewise provides the adjacent end wall of the primary grinding chamber 4. At the opposite end of the primary grinding chamber 4 and forming the end wall thereof is an annular baffle 17 having a central opening 18 which is preferably of substantially the same size as and coaxial with the opening 16. Within the chamber 4 is a circumferential rubber liner 19 coextensive longitudinally with the chamber and forming a closed and continuous circumferential wall thereof. The liner 19 not only extends the full width of the circumferential wall but, also, at the discharge end of the chamber 4, overlies a portion of the annular baffle 17 part way from its circumference toward the center, as indicated at 20. The exposed surface of the portion 20 and of the circumferential portion of the liner 19 merge on a gradual curve, as indicated at 21, for purposes later to be described.

Referring next to the rotors of the primary grinding chamber, each of these comprises generally a hub fixedly secured to the shaft 10 and having a plurality of radial spokes 23, four spokes being provided in the form illustrated. To the end portions of these spokes are secured grinding paddles 24, each of which is disposed relative to the liner 19 so as to pass in closely spaced relation thereto as the rotor rotates. As most clearly illustrated in Fig. 4, each of the spokes is provided on its trailing face with a web 25 which extends from the outer end of the spoke to the leading face of the succeeding adjacent spoke, merging into the adjacent spoke close to the inner edge of the paddle thereon. For example, the webs 25 extend a sufficient distance radially of the rotor to form, when the rotor is operating, a substantially continuous wall in axial alignment with and coextensive radially with the openings 16 and 18, the radii of which passages are substantially equal to the radius from the shaft axis to the inner edges of the paddles 24. Consequently, air passing through the mill cannot flow directly from the opening 16 to the opening 18 but is deflected radially outwardly around the central portion of the rotor and webs and thus across the path of the paddles and through the bed of attrition and thence radially inwardly at the opposite end of the chamber preparatory to entering the opening 18. Along this path the air stream becomes saturated with fine loose material and since its direct flow and velocity are broken up and reduced, the coarse particles tend to settle out, and also are mechanically knocked or deflected out of the air stream and not transported thereby. The webs 25 therefore have a dual function; first, to reinforce the spokes and, secondly, to substantially block the passage of air and pulverized material directly longitudinally of the mill past the central portions of the rotors.

It should be noted, that the corner portions of these paddles 24 which are adjacent the curved portion 21 of the liner, are correspondingly curved, as indicated at 27, so that a full bed of material is provided therebetween and efficient grinding and stirring therealong as well as along the circumferential wall is obtained without undue wear of the paddles or liner. The portion 28 of the baffle 17, between the passage 6 and the portion 20 of the rubber liner slopes axially inwardly toward the midportion of the chamber 4 and the paddles are beveled complementary thereto. As a result any material forced and traveling along the liner portion 20 and not thrown into the path of the paddles by the resiliency of the rubber, does not escape but, by the sloping wall 28 is deflected into overhanging relation to the paddles. Since at this radial position, the centrifugal force is in a direction tending to throw the material radially outwardly, all such material is dropped off of the sloping wall into the path of travel of the paddles and across the air stream. This effects additional stirring of the material and also separation of the finer particles.

To effect more efficient grinding of the material, as will later be described, the paddles 24 of one rotor are staggered with relation to those of the other, for example, the paddles and spokes of the rotor 12 are preferably offset through an angle of 45° circumferentially from those of the rotor 11.

It is apparent that when material to be ground is fed into the chamber 4 and the rotors are revolving at high speed, all such material is thrown to the circumference of the chamber 4 and is forced outwardly against the liner 19 by centrifugal force of the material traveling in front of the working faces of the paddles and by centrifugal force of additional material fed into the mill, and temporarily disposed between the spokes. Due to the resiliency of the liner 19, as the coarser particles are thrown out under centrifugal force and forced outwardly, the liner depresses a sufficient amount to pocket partially the particles of material lying directly thereagainst. The greater the speed of the rotors, the more effectively are the particles pocketed. This action retards the circumferential travel of the outer stratum of material. The inner or overlying strata, not being impeded in this manner and more directly under the influence of the paddles, is moved far more rapidly circumferentially than the outer stratum and thus is rubbed against the outer stratum under the high pressure resulting from centrifugal force, and efficient mutual attrition of the commingling surface particles of the strata results. Again, since the inner stratum is moved circumferentially by the rotors and thrown outwardly in this manner by centrifugal force and since the pressure under the ends of the paddles is somewhat relieved by the rubber liner, the wear on the paddles is greatly reduced as they themselves do not directly rub either stratum of material under high pressure but only propel one strata along the other by a direct push of their leading faces. Thus all material fed into the primary grinding chamber passes outwardly toward the liner 19 and therealong toward the discharge end of the chamber. Material that becomes finely enough ground to float in the air stream passing through the chamber is carried out and the coarser material remaining in the chamber is subjected to additional grinding.

Referring next to the side wall 20, since the material is fed into the chamber at the opposite end therefrom, the material entering tends to progress the material already in the chamber toward the wall 20 and force it bodily along the wall toward the axis of the mill and thus allow it to pass out of the opening 18. However, since the liner 20 is also soft and resilient, this passage of material is greatly reduced, the material at this portion being subject not only to the retarding effect of the liner but also to the opposing centrifugal force. Furthermore, as materials tend to pack at this portion and creep up the liner toward the axis of the mill they are continuously forced by the liner back out into the path of the paddles. For example, they are pressed firmly against the liner and compress it during the passage of a paddle past any portion but immediately the paddle has passed such compressed portion of the liner, this portion again assumes a normal uncompressed condition and forces the material back out into the path of the paddles, preventing it from packing and lying along the wall 20. If sufficient material, by any chance, remains against the wall 20, it is ground by the paddles 26. Due to the rounded portion 21 of the liner and the rounded portion 27 of the paddles, and due to the fact that the paddles are spaced a somewhat greater distance from the liner 19 than from the wall portions 20 and 21, the material may travel across the mill up the wall 20 a sufficient amount to be again thrown out into the path of the rotors. Thus the material is not only prevented from entering the opening before it is fully ground but it is also continuously stirred up and dropped across the air stream so that any fine particles which have become entrapped are again released and can be caught in the air stream and carried out, while the coarser particles are again passed to the grinding strata.

This same stirring effect, but in a lesser degree, is provided along the circumferential wall by the liner 19 so that a packed bed of fine materials such as would become packed against a rigid back wall never results. Instead, the outer strata is always sufficiently loose to permit the finer material to be carried out by the air stream passing through the mill. As stated, the air must pass along and over the material strata on the liner 19 and wall 20, and the stirring effects along both of these walls causes the fine particles of material to be exposed more freely to the air stream at all times so that they may enter and be transported by this stream substantially concurrently upon their reduction to a sufficient fineness to float therein. Consequently, ground material which has already been reduced to the required fineness is not additionally subjected to the effect of the rotors nor additionally pushed around the interior of the mill. Several effects result from this, especially in combination with the control vanes and arrangement of paddles, later to be described, namely; a saving in power inasmuch as already ground material is not additionally stirred or moved about; the mutual attrition of the larger particles is not reduced due to a protective covering of already fine materials; the power requirements are less; and the relative capacity of the mill increased.

Next it should be noted that the paddles 24 are disposed on a bias to a plane through the axis of their rotor, and, of course, to their paths of travel, both sets of paddles having their outermost edges disposed in slightly leading relation to their adjacent or inner edges. For example, both may be disposed at an angle of 5° to a plane through the axis of the shaft 10. Consequently, any material entering the grinding chamber 4 is forced by the paddles of the rotor 11 toward the center of the chamber and into the path of the paddles of the rotor 12, and, liketwise, any material near the discharge end of the chamber, which passes into the path of the paddles of rotor 12 is forced back into the path of the paddles of rotor 11. Thus the material is moved along a sinuous path of travel, being additionally stirred and moved to and fro transversely of its circumferential path of travel concurrently with its circumferential travel. The adjacent edges of the paddles of the two sets preferably overlap a common portion of the paths of travel in those instances in which the sets are staggered. Thus material is urged by the paddles 24 of each of set toward the other set and partially into the path theerof. When the paddles are offset circumferentially, ample time is permitted for unimpeded movement of the material to and fro in this manner. This results in additional stirring of the material so that the fines may readily be freed and caught in the air stream and carried out.

In order to feed materials into the chamber 4, a chute 31 is provided. The chute extends from the outside of the mill through the outer and inner end walls of the air inlet housing 2 on a bias across the interior thereof and is uncommunicated therewith. The inner or discharge end 33 of the chute opens into the primary grinding chamber below and offset from the axis of the chamber and spaced from the opening 16, as better illustrated in Figs. 2 and 3. Thus the material from the chute passes into the chamber 4 and is discharged thereinto inwardly of the rotors from the paddles so as to be caught and thrown radially outwardly by the paddles at high velocity toward the circumference of the chamber. The baffle wall 15 of the inlet housing, forming also the wall of the grinding chamber 4, is provided with an inturned flange 34 about the opening 16 protruding into the chamber 4 to prevent fractured materials from bounding out through the opening 16 and into the air stream entering the opening 16.

The material to be ground is fed into the chute 31 from a suitable hopper 35 which is detachably connected to the inlet chute 31 through the medium of companion flanges.

In present attrition mills, the material to be ground and the air are introduced through the same passage. Consequently, the air entering the mill is varied in inverse relation to the feed of material by virtue of the material blocking the air inlet passage to a greater or less extent as the amount of material fed is varied. If the mill is to be effective and the fineness of grind accurately controlled throughout a wide range of capacity and fineness, some means must be provided to control the rate of feed of material and the air independently. For example, if it is desired to grind only a small slowly fed amount of material, the small amount passing into the chute may be inadequate to fill the chute and air would enter therethrough with the material and thus vary the fineness of grind due to increase in velocity of the air stream. To prevent the entrance of air through the chute, even when only a small stream of material is being passed therethrough, there is provided in the present instance, at the point of connection between the hopper and inlet chute, a throat 36 having an annular flange 36a adapted to be received between the companion flanges of the hopper and chute so that it may be readily installed. The throat 36 is in the form of a frustro-conical shell having its smaller base disposed downwardly, the smaller base being of less diameter than the chute 31 so that as the material passes the throat and enters the lower portion of the chute it is loose and will pass readily into the grinding chamber without danger of becoming packed in the chute. By inserting different sizes of throats, 36, the passage of material from the hopper into the mill can be effected without admission of any substantial amount of air with the material within the range at which the mill is to operate, as the lower base of the throat is proportioned so as to be substantially filled by the amount of material normally being fed. Air is accordingly admitted through a separate inlet, uncommunicated with the chute 31 and adjustable independently thereof, as will later be described.

Referring next to the secondary grinding chamber 5, this chamber corresponds to the primary chamber 4. In the form shown, however, only one set of paddles is provided. These paddles 40 are in more closely spaced relation to the circumferential wall 41 of the grinding chamber inasmuch as only a small portion of the material fed into the mill is ground in the secondary chamber, a large portion of the material passing out of the primary chamber as "fines" of sufficient fineness to require no further grinding in the secondary chamber. If desired, however, the secondary chamber can be so arranged so that a still finer grind of all the material is effected.

In order to maintain a flow of air through the mill for carrying out the finely ground and comminuted particles, the fan 14 is provided at the discharge end of the mill. Thus all the material passing through the grinding chamber is drawn into the fan chamber and by the fan is discharged at relatively high velocity to the points of application; for example, in the case of fuel, to a suitable burner, or in the case of pigments and the like to a suitable air flotation separator.

In order to more accurately control the fineness of grind throughout a wide range of rates of feed, there is provided intermediate the primary and secondary chambers, preferably within and adjacent the inlet passage 6 of the secondary chamber, a centrifugal separator 43 which is better illustrated in Fig. 6. This separator comprises a plurality of circumferentially spaced radial baffles 44 secured onto the shaft 10 and rotatable therewith at shaft speed. If extreme fineness is required, the space between the baffles may be provided with screening of the desired mesh, as indicated at 45. Obviously, all materials carried in the air stream from the primary chamber are discharged into the centrifugal separator 43.

The baffles of the separator are comparatively wide axially of the mill and are arranged so closely together, that, at the usual operating speed of the mill, the speed of travel of the coarser material axially of the mill is not sufficient to carry it the width of the baffle 44 during the passage of two successive adjacent baffles. Consequently, such material is struck by the baffles and thrown at high velocity outwardly to the circumference of the secondary grinding chamber where any coarser particles are ground before passing through the mill. The baffles 44 terminate radially close to the inner end of the paddles 40 so that the fine materials and air may pass across the secondary chamber within the radial limits of the paddles 40. Further, the separator acts as a fan for forcing the air from the passage 6 over the circumferential bed of attrition.

As previously described, at the discharge ends of each of the primary and secondary grinding chambers, in the passages 6 and 7, are mounted the directional air control vanes or damper means for the respective chambers. Referring particularly to the control vanes between the primary and secondary chambers, these are shown more clearly in Fig. 5. The passage 6 between the primary and secondary grinding chambers is defined by an annular housing or frame 47 coaxial with the shaft and provided with inwardly extending radial spider arms 48. Carried on the inner ends of the arms 48 is a collar 49 coaxial with the shaft 10 and in slightly spaced relation thereto. Mounted at their inner ends in the collar 49 and extending radially through the housing 47 are a plurality of rock shafts 50a on each of which is carried one of the vanes 50. The outer ends of the shaft 50a are bent over and received in suitable notches in an operating ring 51 rotatably mounted on the outside of the housing 47. Thus upon rotation of the ring 51, the vanes 50 are swung to different angles relative to an axial path of travel of the air through the housing 47.

The vanes 50 are arranged so that they may swing from a substantially closed position to the fully open position illustrated. It should be noted that the vanes 50 extend from their shafts 50a at an angle to a plane through the axis of the passage 6 and are sloped from their shafts toward the rotor in the direction of travel of the rotor. For example, referring to Figs. 4 and 5 and assuming the rotor to be rotating in the direction indicated by the arrow A, the vanes 6 are disposed at an angle such that the air stream passing them must turn abruptly and reverse its direction as indicated by the arrows B. Thus any material passing from the grinding chamber cannot pass directly through the passage 6 but must make an abrupt turn in direction to pass around the vanes. Consequently, any particles traveling due only to mechanically imparted velocity or impact received within the grinding chamber are stopped and deflected back by striking of such particles against the vanes 50, whereupon such particles drop back into the grinding bed. However, any material sufficiently fine to float in the air readily turns abruptly and passes around the vanes.

It is desirable that the vanes 50 be adjusted from the exterior of the mill and for this purpose an operating lever 54 is provided, this lever being connected to the operating ring 51 for rotating the same consequent upon axial movement of the lever. The lever extends through a suitable opening in the casing and is mounted in a suitable housing 55 which is in sealed relation to the housing of the mill about the opening therein. The outer end of the lever 54 is threaded as indicated at 56. Secured to the outer end of the housing 55 and rotatable relative thereto is a hand wheel 57 internally threaded complementary to the threads 56 so that upon rotation of the hand wheel the lever 54 is moved axially inwardly and outwardly of the mill. The inner end of the lever is pivotally connected to the ring 51 in a manner such that, in intermediate position of the vanes 50, the lever is 90° to the radius of the ring through the point of connection. Thus the greatest possible movement of the ring for a given movement of the lever 54 is effected. The vanes 70 in the passage 7 between the secondary grinding chamber 5 and the exhaust fan housing are similarly arranged and are separately controlled independently of the vanes 50 by a corresponding hand wheel.

In the grinding of materials it is quite often desirable to use preheated air so as to more effectively dry the materials and at the same time eliminate undue moisture in the mill which would deleteriously effect the grinding operation and reduce the efficiency thereof. For this purpose the inlet end 58 of the air inlet housing may be placed in communication with a suitable source of preheated air.

For controlling the admission of air into the mill there is provided intermediate the inlet end 58 of the air inlet housing and the source of air a suitable control damper 59 which may be rotated to different positions for changing the effective size of the air inlet passage. For the purposes of illustration, this damper is shown as operated to the desired positions by a lever 60 which, in turn, is operated by suitable gear and spring device. While the lever 60 can be set directly by hand, it is shown as driven by a cam 61 through a gear train from a rotatable shaft 62 so that the amount of air admitted can be proportioned automatically in accordance with the rate of feed of the materials to the mill as is more fully set forth hereinafter and in my copending application, Ser. No. 44,466, filed October 10, 1935, which became Patent No. 2,176,824.

Thus in operation, the amount of air fed into the primary grinding chamber and also its resultant velocity, direction, and flow characteristics through both primary and secondary chambers can be accurately controlled and the fineness of grind regulated.

The mill is preferably operated at constant speed, all regulation of fineness of grinding being effected by control of the air passing through the various chambers by the damper 59, and the directional vanes.

The setting of the vanes 50 relative to the vanes 70 is preferably such that the effective size of the passage 6 is less than the effective size of the passage 7 and is equal to or greater than the greatest passage past the inlet valve 59. Consequently, once the vanes 50 and 70 are set in the desired adjusted position, the flow of air through the mill is directly under the control of the damper 59. By maintaining the vanes 50 in a more nearly closed position than the vanes 70, the velocity of air passing the vanes 50 is increased, due to the Venturi effect and a high velocity discharge stream and reduced atmospheric pressure existing in the passage 6 and at its inlet opening. Thus any material that is actually floating in the air at this opening is quickly transported from the primary grinding chamber. Since this passage discharges into the chamber 5 which is comparatively large, the velocity of the stream is again reduced. However, the particles which are of such fineness as to float in air will pass on with the stream regardless of this reduction in velocity. Due to the slightly higher velocity past the vanes 50, coarse particles may be drawn into the chamber 5 but these are separated by the centrifugal separator 43 or settle out due to the decrease in the velocity of the air stream in the chamber 5. As stated the vanes 70 are kept at a more open position and their capacity is equal to or greater than that of the inlet valve. Consequently, only a slow flow of air therethrough results. Thus in the chamber 4, the fines are drawn out immediately upon separation from the attrition bed even at the expense of drawing through some slightly coarser material. This greatly increases the efficiency of the chamber 4, and, in the chamber 5, such fines as are floating in the air may pass on through the chamber 5 at slower velocity without additional grinding or interference with the grinding therein, but any such coarser particles carried into the chamber are separated and additionally pulverized.

Again, by means of the control vanes, the currents of air through the chambers 4 and 5 can be so controlled that the concurrent increase of air and material supplied to the mill does not cause undue variation in fineness. Since the mill is originally designed for a given fineness while working at capacity, depending on the particular use to which it is to be put, the same fineness for lesser rates of feed of material can readily be attained.

In order that the mill may be assembled and disassembled readily for the installation or removal of any parts, the form illustrated has been found highly practicable. In this form the air inlet housing 2 with its inner wall 15 preferably comprises an integral casting, which is tapped at its outer end to receive the bearing assembly for the shaft 10. The body 1 comprises a cylinder of constant diameter within and having suitable external flanges 65 at each end adapted to engage complementary flanges on the air inlet housing and exhaust fan housing respectively, these housings being secured to the housing 1 by suitable bolts in cooperation with the flanges 65. The exhaust fan housing 3 is likewise a single casting, carrying a bearing for the opposite end of the shaft 10 and provided with an internal annular shoulder 66. The control vane assembly incorporating the passage 7 is in the form of an annular baffle plate 67 snugly fitting within the interior of the housing 1 and provided with a shoulder complementary to the shoulder 66. This plate forms the support for the integral frame 68 defining the passage 7 and also forms the inner end wall of the exhaust fan housing. Assuming the mill is disassembled except that the exhaust fan housing is secured in place and the exhaust fan and shaft 10 installed, the plate 67 can readily be inserted from the opposite end of the mill into place.

Next the secondary grinding chamber is installed. This comprises an annular plate 69 of L-shaped cross section, the circumferential portion of which snugly engages the inner wall of the chamber 1 and the radial wall extends inwardly from the circumference and fits snugly against the inner wall of the frame 68, complementary shoulders being provided on the frame 68 and the plate 69. Obviously, this can readily be inserted from the inlet end of the mill. Next the secondary grinding rotor 13 and centrifugal separator 43 are inserted and secured firmly on the shaft. The plate 71 forms the innermost end wall of the secondary grinding chamber and carries the frame 47. The primary grinding chamber is formed in a similar manner to the secondary and likewise correspondingly arranged with relation to the vane assembly 50. With these two in place, the primary rotors 11 and 12 may be inserted and secured firmly on the shaft by suitable keys or set screws. The air inlet housing is next secured to the flanges 65, its inner wall 15 holding in place the baffle 17 and plate 71. The bearing assembly 8 is next inserted in the air inlet housing and on the shaft and secured in place by suitable bolts thus securing the shaft in place. Thus each of the elements defining the compartments, chambers and housings are held in fixed position by mutual abutment and all may be readily removed from either the inlet end or the outlet end of the mill simply by first removing the shaft bearings and then removing all the interior elements of the mill in assembled condition or by separately and successively removing the operating elements from either end. The shaft bearings 8 and 9 are so arranged that they may be removed bodily and are likewise protected against the infiltration of dust or any foreign matter thereinto. Referring next to the correlation between the rate of feed of material and admission of air, the material to be ground may be fed to the mill hopper 35 by means of a magnetic feed chain and separator more fully set forth in my Patent No. 2,092,025 granted September 7, 1937, which is operated in definite relation to the air inlet damper 59, through the cam and gearing above mentioned.

Briefly, the magnetic feed chain and separator is arranged to discharge continuously into a hopper 35 which, in turn, communicates with the feed chute 31 of the mill. In general, this mechanism comprises a pair of transversely spaced parallel chains 76 arranged to travel horizontally above the open inlet end of the hopper 35. As more clearly illustrated in Fig. 1, each chain has laterally extending prongs 77 which extend toward the opposite chain but terminate in spaced relation thereto, the prongs of one chain preferably being alternated along the path of travel with respect to those of the opposite chain. These chains are driven at the same speed so as to maintain a fixed relation between the prongs 77.

Along one portion of the path of travel of the prongs, the prongs pass beneath the outlet of a fuel hopper 78 which is kept filled with fuel which is fed between the prongs of the chain as the chain moves therebeneath. Beneath this portion of the path of the prongs is a dead plate 79, the dead plate extending from beneath the feed hopper 78 at least as far as the near edge of the hopper 35 so that material will be retained in position to be progressed along this portion of the path by the prongs. Along that portion of the path of travel coextensive with the hopper 35 are longitudinally extending tracks 80 engaging the under surface of the prongs 77 so as to define therewith a checker grill, the tracks 80 preferably being of a material which is not conductive of magnetic flux. Thus material passing out of the hopper 78 between the prongs 77 is moved thereby along the dead plate and tracks 80. When over the tracks 80 and hopper 35, all material of the proper size could normally drop through the resultant grill into the hopper 35.

Along the portion of the path of travel above the hopper 35, the prongs are magnetized so that any tramp or other iron, regardless of size, will be retained on the chain while the fuel may pass into the hopper 35. For accomplishing this purpose, a plurality of electromagnetic coils are provided, these coils being so arranged that one chain and its prongs are responsive only to the north pole of the electromagnetic coils and the other chain and its prongs are responsive only to the south pole. Consequently, alternate ones of the prongs 77 are of opposite polarity. The coils 82 are so arranged as to maintain this magnetic field along that portion of the path of travel above the hopper 35 and for a sufficient distance therebeyond to insure that all iron magnetically retained on the prongs will be carried beyond the remote edge of the hopper 35. Since the prongs are no longer magnetized beyond this point, all such iron and material may drop off.

The magnetic chains may be driven by suitable sprockets 84 carried on a common shaft which, in turn, is driven by a pulley 85. The pulley 85, in turn is driven through the pulleys 86, 87, 88 and 89 in the order enumerated. The pulley 89 is carried on the variable speed shaft of a change speed gearing which is preferably of the V-belt type having a variable speed shaft 90 and a constant speed shaft 91. The variation in the rate of drive of the shaft 90 is effected by movement of the pulley elements 92 toward and away from each other so that the belt 93 rides on the pulley elements 92 at different distances from the axis, depending upon the distance of the pulley elements from each other.

In order to move the pulley elements to the desired positions for the speed required, a hand wheel 94 may be utilized but, since it is generally desirable to control the speed in response to temperature changes, boiler pressures and the like, the pulley elements 92 are also operable toward and away from each other by a pilot motor 95 which may be responsive to a suitable control switch which operates in accordance with the boiler pressure, room temperature etc., as desired, in a well known manner.

As previously set forth, it is desirable that the volume of air admitted to the mill be controlled in a direct proportional relation to the rate of feed of the fuel and consequently the damper 59 may be controlled by the reversible pilot motor 95. This control is effected by maintaining a desired geared relation between the rotatable shaft 96 of the pilot motor 95 and the shaft 62 which operates the damper, operating lever 60, in turn, through the medium of a cam 97 and toggle links, as illustrated in Fig. 2.

The change speed gearing may be driven from any suitable source of power, for example, from the motor M which is of sufficient power to drive the feed mechanism for all mill capacities.

Since the mill is often used in connection with a fuel burning system, it is necessary to supply an auxiliary means for utilizing oil in case of the exhaustion of the supply of coal or for some other reason and for this purpose, a hand operated clutch 99 is provided for disassociating the particular chain feed and driving mechanism. A similar hand operated clutch 100 is utilized for immediately connecting the change speed mechanism to a suitable oil pump 101 so that the changeover can be made without any break in operation. Since it is also desirable to vary the amount of secondary air supplied to the fuel burners in proportion to the variations in the rate of feed of the fuel, an operating lever 102 may be provided, this being connected through a suitable link arrangement to the lever 60 so that the secondary air damper (not shown) and damper 59 may be operated in a definite relation to each other.

While I have described briefly the feed mechanism for use in connection with the present mill and means for maintaining the desired relation between the rate of feed and grinding, the admission of air to the mill, and of secondary air to burners, in case of pulverized fuel, the specific structure for these purposes herein briefly described is more fully described and claimed in my Patent No. 2,092,025 granted September 7, 1937.

Having thus described my invention, I claim:

1. In an attrition grinding mill comprising a grinding chamber having a passage for admitting materials to be ground into the chamber, and a circumferentially closed wall and a side wall at an abrupt angle to the circumferential wall, a rotor within the chamber, a plurality of circumferentially spaced radial paddles on said rotor, the outer ends of the paddles being in closely spaced relation to the circumferential wall and

the outer radially extending edge portions of each being in closely spaced relation to the side wall, the interior faces of said circumferential wall and side wall being resilient rubber and joined by a gradually curved rubber wall portion.

2. In an attrition mill comprising a grinding chamber having side walls and an imperforate circumferential wall, means to feed materials into the interior of the chamber, a rotary grinding means within said chamber, one of said side walls having a passage therethrough, means to maintain a flow of air through said passage and chamber, and adjustable directional vanes cooperable with the passage to vary the volume and direction of the air stream passing through said chamber.

3. In an attrition mill comprising a grinding chamber having side walls and an imperforate circumferential wall, means for feeding materials into the interior of the chamber, a rotary grinding means within said chamber, one of said side walls having an air inlet passage and the other having an air discharge passage coaxial with the chamber, means to maintain a stream of air through said chamber and out through the discharge passage, and a plurality of sets of radial vanes cooperable with the passages respectively, vanes of each set being rotatable in unison with others of the same set to different adjusted positions about their respective radially extending axes to vary the direction of the air stream passing through their associated passage, and means disposed exteriorly of the chamber and operatively connected to the sets of vanes respectively for adjusting the position of the vanes about their respective axes.

4. In an attrition mill comprising a grinding chamber having side walls and an imperforate circumferential wall therebetween, means for feeding materials into the chamber, a rotary grinding means within the chamber, one of said side walls having an air intake passage and the other wall having an air discharge passage, one of said passages being coaxial with the chamber, means to maintain a stream of air through said chamber from the inlet passage, a plurality of vanes cooperable with one of said coaxial passages, means mounting said vanes for rotation to different adjusted positions about respective axes extending substantially radially of the passage with which the vanes are associated, and means operatively connected to the vanes for rotating the same about the respective axes to different adjusted positions.

5. In an attrition grinding mill, a cylindrical casing, a coaxial fan housing secured to one end thereof and removable axially therefrom, a coaxial air inlet housing secured to the opposite end of the casing and removable axially therefrom, said air inlet housing having an annular radially extending inner end wall, coaxial bearings in the housings, a shaft rotatably mounted in said bearings, a pulverizing rotor on said shaft, an annular sleeve insertable axially in the casing from one end of the casing and snugly received coaxially in the casing with one end abutting the annular end wall of the air inlet housing, an annular radial flange at the opposite end of the sleeve extending radially inwardly from the circumferential wall thereof, said sleeve walls and air inlet wall providing a grinding trough, and means receivable axially in the casing and abutting the flange end of the sleeve at one end and abutting the fan housing at the other end for holding the sleeve in said position axially of the casing, whereby all parts of the mill may be removed readily axially from the casing.

6. In an attrition grinding mill comprising a grinding chamber having a circumferentially closed wall and a passage for admission of materials to be ground into the chamber, means to maintain a flow of air through the chamber, a rotor within the chamber, and a plurality of circumferentially spaced radial paddles on said rotor, a resilient rubber side wall contiguous to the circumferential wall, the outer ends of the paddles being in spaced relation to the circumferential wall and the outer edge portion of each being in spaced relation to the side wall, and said paddles sloping across their path of travel in a direction to urge the material being ground toward and against said resilient side wall.

7. An attrition grinding mill, comprising circumferentially closed communicating primary and secondary grinding chambers, means for feeding materials to be ground into the primary chamber, grinding rotors mounted within the chambers, respectively, means to maintain a flow of air progressively through the chambers, and an adjustable set of circumferentially spaced and radially disposed vanes which are tiltable about radially extending axes, said vanes being disposed intermediate said chambers and operable to vary the air currents in the chambers when adjusted to different predetermined positions.

8. In an attrition grinding mill comprising a grinding chamber having a circumferentially closed wall, means for admitting loose material to be ground into said chamber, a rotor within the chamber, and a plurality of circumferentially spaced paddles on said rotor, each paddle having a blade portion which is narrow circumferentially of the chamber and has an outwardly disposed end surface which extends generally longitudinally of the rotor axis and which is narrow in relation to the circumferential spacing of said end surfaces, means overlying said circumferentially closed wall and exposed toward the said end surfaces with uniform radial clearance therefrom continuously around the circumference of the said means, said means being sufficiently resilient to be compressed by centrifugal force of the material pushed by the paddles and thereby to partially pocket temporarily particles of the outer stratum of said material when the rotor is turned at high speed and to return toward normal condition, at the instant after passage thereover of a paddle and the material being pushed thereby, for loosening the outer stratum of the bed of material disposed on said means outwardly beyond the radial extremities of the paddles and thereby freeing fine particles, said end surfaces being spaced closely to the said means to limit the depth of said outer stratum of material so that said stratum can be loosened for its full depth by said return of each portion of said means immediately after passage of each paddle thereover, and said paddles being widely spaced circumferentially to such extent that material being pushed by a padlle is spaced to the rear of the immediately preceding paddle so as to provide, at the rear of each paddle, a space of substantial circumferential extent and which is free of pushed material, whereby the return of the said means is unimpeded radially by material being pushed by the next succeeding paddle.

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