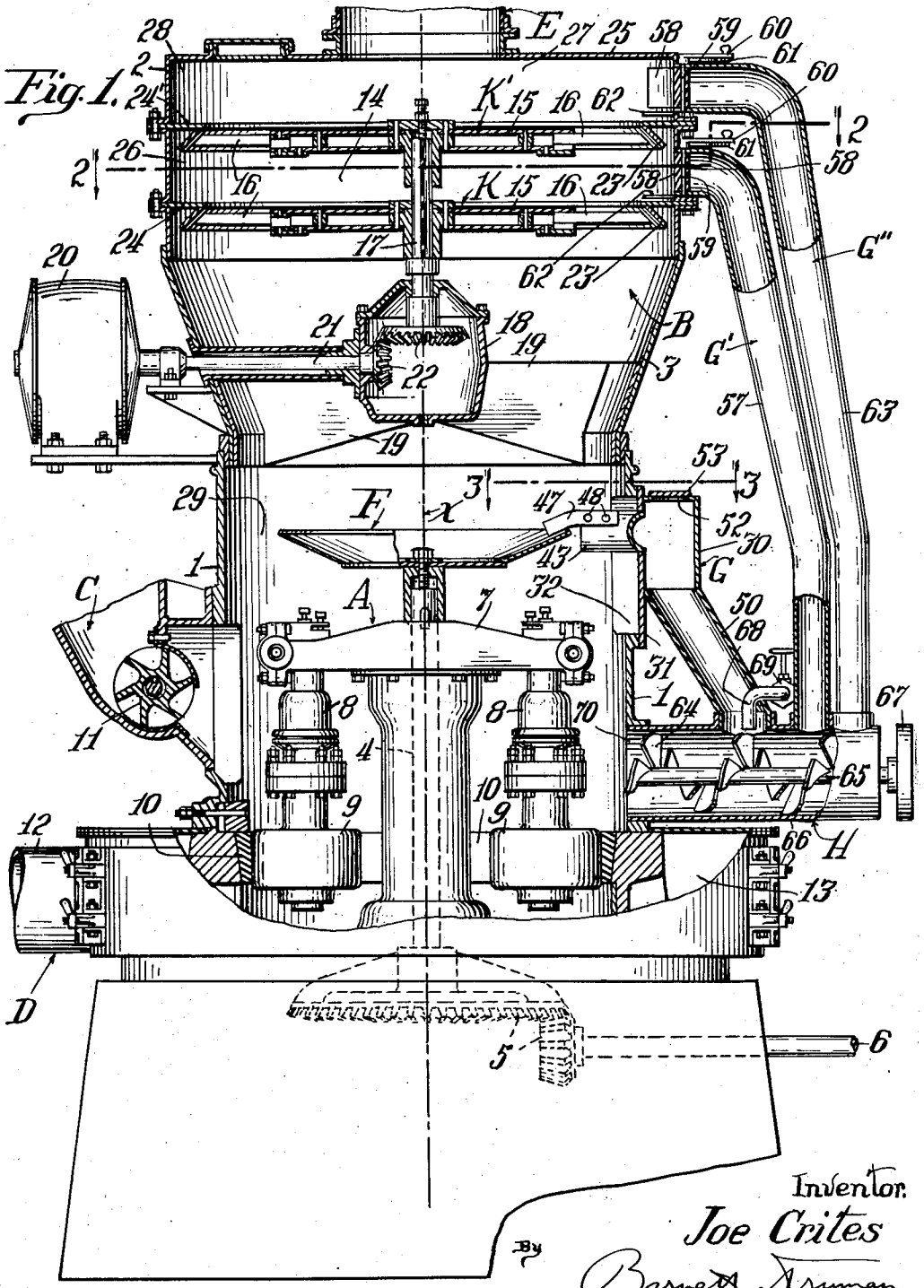
May 14, 1940. J. CRITES 2,200,822

GRINDING PROCESS AND APPARATUS

Filed Oct. 15, 1937 2 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

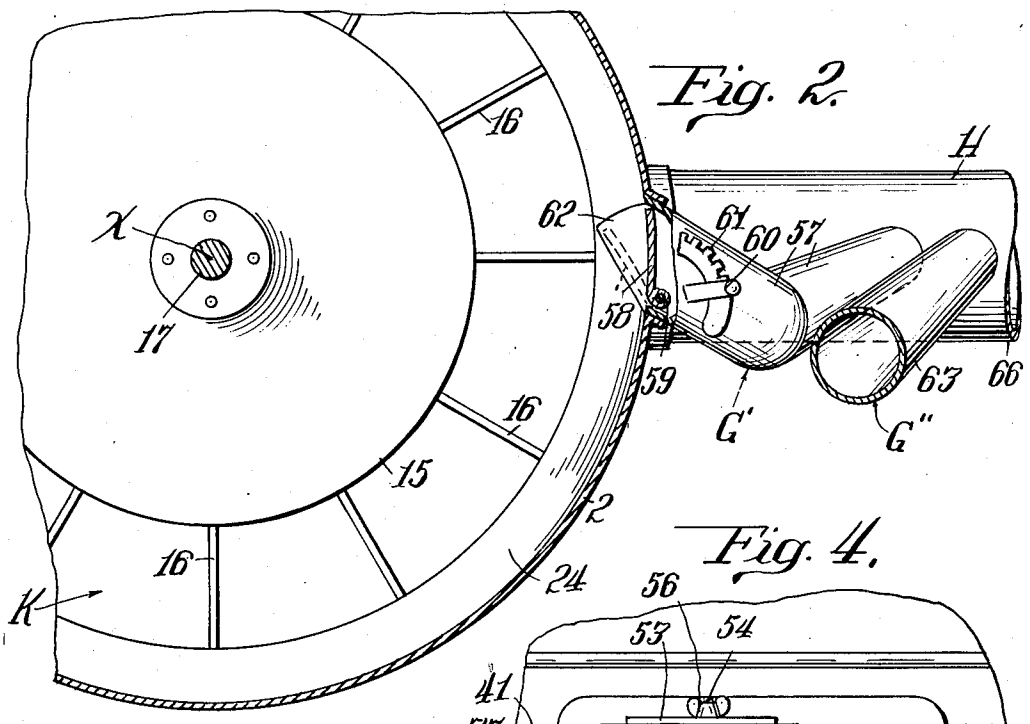


Fig. 4.

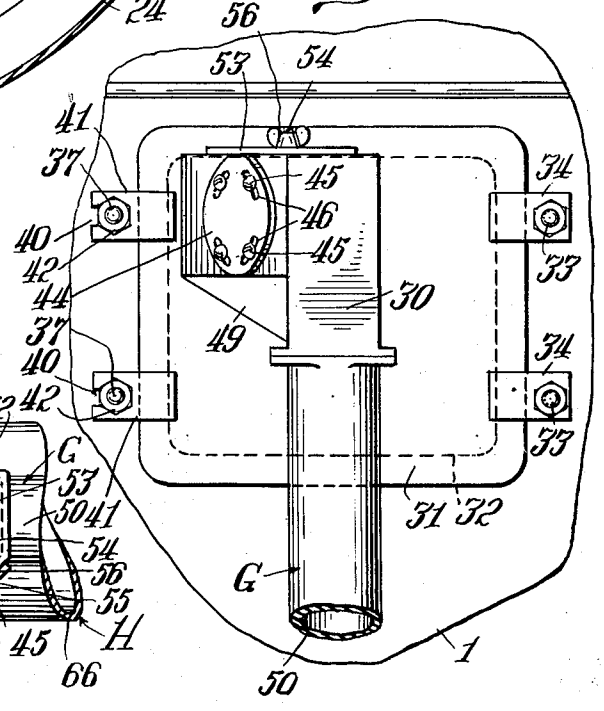
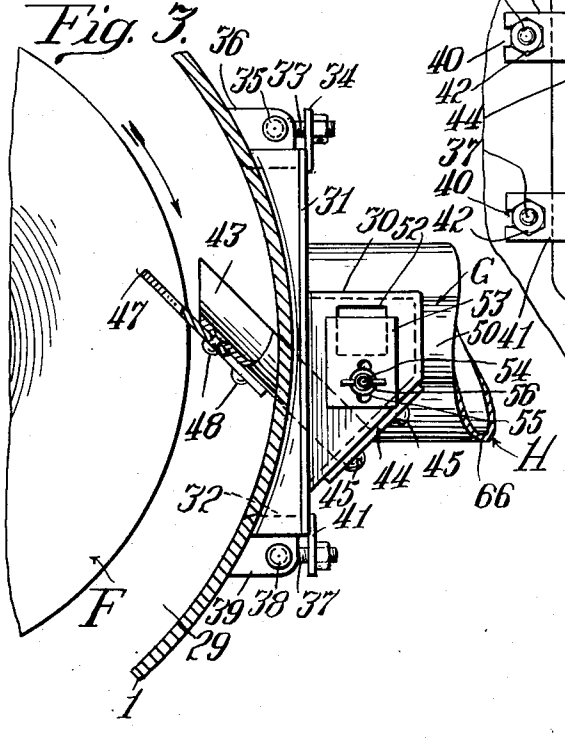


Fig. 3.



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UNITED STATES PATENT OFFICE

2,200,822

GRINDING PROCESS AND APPARATUS

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Application October 15, 1937, Serial No. 169,200

9 Claims. (Cl. 83—45)

This invention relates to a new and improved grinding process and apparatus, and relates more particularly to an improved method and means for facilitating the grinding or pulverizing of finely divided material.

In one well known grinding system, the material to be ground or pulverized is introduced into a mill comprising rotating rollers or hammers, and an air stream passed through the mill carries out material sufficiently ground to be capable of suspension in the air stream. This air stream is then passed through a separator wherein the insufficiently pulverized material is rejected (and usually returned to the mill for further grinding) the air stream carrying out only the sufficiently pulverized material which is subsequently separated from the stream. The insufficiently pulverized material which is rejected by the air stream and returned to the mill is often of such a fine grade that it cannot be efficiently handled by the mill. In the case of a hammer mill, the hammers can exert but little impact on a fine particle because of the inertia of the fine particle and because the windage from the hammers blows the fine particles out of the path of the hammer. In a roller mill difficulty is encountered because the finely pulverized materials flow like water and are carried out of the path of the rollers by the air currents set up within the mill.

The broad principle of the present invention consists in withdrawing these fine tailings or insufficiently pulverized material which are rejected by the separator and mixing these materials with a small quantity of water or other temporary binding agent thus forming a paste or other conglomerate having sufficient bulk to resist the air currents within the mill, this mixture being returned to the mill for further treatment between the grinding elements. The air stream passed through the mill is heated so that the water or other temporary binding agent will be evaporated and withdrawn by the air stream as the materials in the mixture thus introduced are pulverized.

The principal object of this invention is to provide an improved process and apparatus for grinding fine materials as hereinabove briefly described and disclosed more in detail in the specifications which follow.

Another object is to provide an improved process for increasing the bulk and facilitating the handling of fine materials during a grinding operation.

Another object is to provide improved means for selectively withdrawing materials of various grades from a grinding and separating apparatus.

Other objects and advantages of this invention will be more apparent from the following detailed description of one approved form of apparatus designed and operating according to the principles of this invention.

In the accompanying drawings:

Fig. 1 is a central vertical section (with parts shown in elevation) of the assembled grinding and separating apparatus.

Fig. 2 is a horizontal section, on a somewhat larger scale, substantially on the line 2—2 of Fig. 1.

Fig. 3 is a partial horizontal section taken substantially on the line 3—3 of Fig. 1.

Fig. 4 is a partial elevation, looking from the right at the apparatus shown in Fig. 3.

The apparatus comprises, in general, a closed upright continuous casing in the lower portion of which is located the grinding mechanism A, and in the upper portion of which is located the separating apparatus B. At C is indicated means for feeding material to be ground or pulverized to the mill A, while at D is indicated means for feeding heated air or other gases to the mill, the air stream flowing upwardly through the mill and separator B and out through conduit E with sufficiently pulverized material in suspension. A means F positioned intermediate the separator and mill is adapted to collect the heavier tailings rejected by the separator, and at G, G' and G'' are indicated means for withdrawing rejected material from different portions of the assembly and delivering this material into a mixer H to form the paste or conglomerate that is delivered back into the mill A for further treatment.

The enclosing upright housing or casing which is preferably centered about the central vertical axis x comprises a lower cylindrical portion 1 in which mill A is housed, an upper cylindrical portion 2 of somewhat greater diameter which houses the separator mechanism B, and an intermediate upwardly expanding conical portion 3.

The mill A, in the example here shown, is of the well known roller type and comprises the central vertical drive shaft 4 journaled in suitable bearings and rotated through bevel gearing 5 from the drive shaft 6. The spider 7 carried at the upper end of shaft 4 supports a circular series of roller-carriers 8 each pivoted in the spider so that the grinding rollers 9 supported by the carriers 8 may swing radially outward from the central axis x under the influence of centrifugal force as the spider is rotated. The rollers 9 are freely rotated about their own axes and as they swing outwardly will engage the stationary bull-ring 10 and roll

thereon. The material to be ground is delivered into the mill housing by any suitable means such as the pocketed feeder shown at 11 and comprising a portion of the feeding assembly C, this material falling downwardly between the grinding rollers 9 and bull-ring 10 so as to be crushed or pulverized therebetween. The air-supplying means D comprises a conduit 12 leading from any suitable source of heated air or other gases into the annular manifold 13 surrounding the mill. The air stream delivered from manifold 13 flows upwardly through casing 1 carrying in suspension material that has been sufficiently finely divided by the mill to be capable of such flotation.

The separator B is preferably of the general type disclosed in the copending application of Joe Crites, Serial No. 132,784, filed March 24, 1937, which became Patent No. 2,169,680 on August 15, 1939, and comprises a pair of similar separating assemblies K and K' with an intermediate centrifugal sorting zone 14. These two separating assemblies K and K' are similar to one another and each comprises a central rotary element or "whizzer" journaled for rotation about the central axis x and consisting of a central disk or deflector 15 from which projects outwardly a circular series of substantially radial vanes 16, these vanes being positioned vertically so as to present a minimum of obstruction to the upwardly flowing air stream. This rotary "whizzer" is carried by a vertical shaft 17 journaled in gear casing 18 supported from the outer casing 3 by a plurality of radially extending plates 19. The whizzers are rotated by any suitable means, preferably a motor 20 connected through horizontal motor shaft 21 and bevel gearing 22 journaled in gear casing 18 with the lower end of vertical whizzer shaft 17. The outer ends of vanes 16 are beveled inwardly and upwardly and rotate in close proximity to the lower surface of a downwardly and outwardly projecting annular conical deflector 23 carried by casing 2. The supporting means comprises an annular inwardly projecting plate 24 which extends as a shelf over the upper outer end portions of vanes 16. The upper end of the outer peripheral casing 2 is closed by a cover plate 25 from the central portion of which projects the outlet conduit E. The air flow through the apparatus is preferably created and maintained by an exhaust fan or blower which draws air upwardly and outwardly through the conduit E. It will be understood that only sufficiently pulverized material is carried in suspension through this outlet conduit which leads into a suitable cyclone separator or other means for depositing the pulverized material from the air stream.

It will be noted that the only passage for this air stream through the separating assembly K is through the annular space between the central disk or deflector 15 and the outer stationary annular deflector 23, and between the rapidly rotating vanes 16 which cut across this annular space. Only the very finely divided particles of material held in suspension in the air stream will find their way upwardly between these vanes. The greater portion of the material above a certain size will be thrown outwardly against the stationary deflector 23 and thence directed downwardly through casing 3. The portion of the air stream in the intermediate classifying zone 14 between the two separating assemblies K and K' will be caused to rotate by the rotary whizzers above and below this space so that the larger and heavier particles of material in the air stream which have passed separator K will be thrown outwardly into the peripheral portion 26 of this zone adjacent the enclosing wall 2. The material which passes separating zone 14 will have to pass through the upper separating assembly K' in which another separating action, similar to that performed by the lower separator K, will take place. A last centrifugal sorting operation will be performed on the whirling air stream which passes the upper separator K' so that the heavier particles of material which have passed the two separating assemblies will be concentrated in the outer portion 28 of the upper centrifugal sorting zone 27. It will thus be seen that only the most finely divided and pulverized material will eventually be carried out in suspension in the air stream through outlet conduit E. The fineness of this delivered material may be varied, within certain limits, by changing the speed of rotation of the rotary whizzer, and consequently a variable speed driving means is preferred. This may be accomplished by using a variable speed motor 20 or by inserting suitable change-speed mechanism between the motor and the shafts driven thereby.

The material rejected in the outer zone 28 of upper sorting space 27 will collect upon the upper shelf 24' and gradually find its way back between the rotating vanes of whizzer K' so that it will join the material rejected by whizzer K' and the material separated by centrifugal sorting action in the outer portion 26 of the intermediate zone 14 and all of this material will be deposited on the lower shelf 24 and work it way back through the lower whizzer. This material, together with the material initially rejected by the lower whizzer and thrown downwardly by deflector 23 will settle downwardly toward the mill A.

The centrally positioned deflector and collection receptacle F is preferably supported for rotation on the upper end of mill shaft 4. This deflector is preferably dished upwardly or saucer-shaped and its outer peripheral edge is spaced from the adjacent inner wall of casing 1 so as to provide an annular air space 29 through which the upwardly flowing air stream is forced to pass. This upwardly flowing air stream with its suspended material is rotating or whirling due to the motion imparted thereby by mill A and deflector F and will tend to follow the inner wall of casings 1 and 3 as it moves upwardly toward the separator K. As a consequence, the material rejected by the separators tends to settle downwardly through the central quieter portion of the enclosure which is less agitated and where the upward air velocity is lowest. This material will for the most part be collected on or in the deflecting receptacle F. This material will unavoidably contain, along with the properly rejected or oversized material, a considerable amount of already sufficiently pulverized material which can eventually pass through the separators without further grinding treatment. As the material collected on deflector F is thrown outwardly by centrifugal force this finer material will be caught up by the air stream flowing upwardly through passage 29 and will eventually pass through the separators. This material returned from deflector F increases the saturation of the air stream at the separator and consequently increases the efficiency of the separator. Also by preventing the return of this already sufficiently pulverized material to mill A, the capacity of the mill for handling new material is increased. The larger and heavier material collected on receptacle F

and thrown out horizontally against the outer casing 1 will eventually find its way back downwardly into the mill for further grinding treatment unless some means such as that indicated at G is provided for withdrawing this material from the mill separator assembly.

A large portion of this rejected material that is not sufficiently pulverized and needs further grinding treatment is, however, already so finely divided that it is very easily deflected or carried away by the air current set up within the mill and finds its way with difficulty back between the grinding elements 9 and 10. This fine material tends to float away or be blown out of the path of the rollers, and similar difficulties will be encountered with other types of grinding apparatus such as a hammer or impact mill.

According to the present invention, the material rejected by the separator is withdrawn from the mill-separator assembly and mixed with a small quantity of water or some other temporary binding agent so as to form a paste or conglomerate mixture of larger and heavier units that may be more readily returned to the mill and delivered to the grinding elements for further treatment.

The withdrawing mechanism G comprises a throw-out pocket 30 carried by a supporting plate 31 removably secured over an opening 32 in one side of mill-casing 1. In the example here shown a pair of bolts 33 secured in ears 34 projecting from one side of plate 31 (see Figs. 3 and 4) are pivotally mounted at 35 in ears 36 projecting from casing 1. A similar pair of bolts 37 pivoted at 38 in ears 39 on the casing engage in slots 40 formed in ears 41 projecting from the opposite side of plate 31. By loosening the nuts 42 on bolts 37, these bolts may be swung out of slots 40 after which the plate or door 31 can be swung away from the casing about the hinge axis 35. This will permit access to the interior of the casing. The throw-out pocket 30, in the form of a substantially closed casing, is mounted on the outside of plate 31. A substantially semi-cylindrical scoop 43 is secured at its outer end to a plate 44 mounted for rotary adjustment by means of bolts 45 secured in one side wall of casing 30 and projecting through slots 46 in plate 44. This adjustment permits the scoop to be rotated around the central longitudinal axis of the cylinder so as to be presented at the most desirable angle to the air stream within casing 1. This scoop 43 projects inwardly through a suitable opening in supporting plate 31 so that the inner end of the scoop is positioned adjacent the peripheral edge of rotary deflector or receptacle F. Preferably the scoop projects inwardly at an angle opposed to the direction of rotation of the whirling materials within the casing, this direction being indicated by the arrow in Fig. 3. A scraper 47 may be secured at 48 to the inner end portion of scoop 43, this scraper projecting inwardly over the outer upper surface of deflector F in position to scrape or dislodge materials therefrom.

The lower portion of the pocket or casing 30 is in the form of a chute 49 leading into conduit 50 through which the collected materials are discharged into the mixer H. An opening 52 in the top of casing 30 is partially closed by cover plate 53 held in place by bolt 54 projecting through slot 55 in plate 53 and provided with the holding nut 56. This provides an air inlet opening which may be adjusted in size by properly positioning the closure plate 53, thus controlling the draft through conduit 50.

The collecting means G' comprises a conduit 57 which leads from an opening formed in the peripheral wall 2 of the separator casing where this wall surrounds the intermediate centrifugal sorting space 14. The upper entrance end of conduit 57 may be closed by a door or damper 58 pivoted at one edge on shaft 59 provided at its upper end with an operating crank 60 adjustable along the arcuate guide plate 61. The door 58 is curved to conform with the curvature of wall 2 and when in the inoperative position shown in solid lines in Fig. 2 will form substantially a continuation of this wall. Just below the swinging door 58, a sector shaped plate or shelf 62 projects into the centrifugal sorting space 14. With the door or damper 58 in the position shown in full lines in Fig. 2 no material will be withdrawn through conduit 57. However, if door 58 is adjusted inwardly to some such position as shown in dotted lines it will serve as a scoop to collect material (above and upon the shelf 62) and direct this material into the conduit 57 and thence downwardly into mixer H into which this conduit discharges. The percentage of material withdrawn in this manner may be adjusted by changing the position of scoop 58 by means of adjustable handle 60.

The collecting means G'' is substantially the same in all respects as the means G' and includes a conduit 63 also discharging into mixer H. The collecting means G'' communicates with the centrifugal sorting space 27 above the upper whizzer assembly K'.

It will now be apparent that any one or all of the collecting means G, G' or G'' may be used to withdraw material of various grades from different parts of the mill-separator assembly. The coarsest tailings will be withdrawn through apparatus G, and the finest rejected material through apparatus G''.

The mixer H may be in the form of a pug-mill, or a spiral conveyor 64 mounted on shaft 65 rotatable in the substantially horizontal cylindrical conduit 66, shaft 65 being rotated by any suitable means such as the outside pulley indicated at 67. The several conduits 50, 57 and 63 discharge into the mixer conduit or casing 66, and any suitable means is provided for sprinkling or admitting water into the mixer. This water-feed means is here shown as a pipe 68 provided with a control valve 69. The conveyor 64 is preferably of the cut-flight type as shown so that the tailings and water or other suitable temporary binding agent will be thoroughly mixed and slowly advanced toward the discharge end 70 of the mixer from which they are delivered into the mill housing so as to fall between the grinding elements 9 and 10. It will be understood that only sufficient water or other agent is added to temporarily bind the fine tailing particles together so as to form either a paste or a loose conglomerate having sufficient bulk and weight to resist the air currents within the mill so that the material will be readily delivered between the relatively rotatable grinding elements.

By simply heating the air stream delivered into the mill to a sufficiently high temperature, the water will be evaporated as the grinding process is performed so that the finely pulverized material particles will be again released for separate flotation in the air stream.

Instead of utilizing a mixer H of the general type here shown, the withdrawn tailings could al-

ternatively be combined with water or other temporary binding agent to form pellets or briquets of any suitable size, these pellets or briquets then being sent back into the mill either through feeder C or a separate feeder as may be found desirable.

I claim:

1. In combination, a mill comprising relatively moving grinding elements, means for feeding dry material to be ground into the mill, a separator above and communicating with the mill, means for passing a stream of heated air through the mill and separator, ground material being carried in suspension in the air stream upwardly from the mill into the separator and sufficiently pulverized material being carried from the separator in the air stream while insufficiently pulverized material is rejected by the separator, means for collecting and withdrawing this rejected material comprising a rotating receptacle positioned in the path of the air stream intermediate the mill and separator and a scoop positioned to withdraw material collected on and thrown outwardly by the receptacle, and means for mixing a temporary binding agent with the withdrawn material and returning the mixture for further treatment by the grinding elements.

2. In combination, a mill comprising relatively moving grinding elements, means for feeding dry material to be ground into the mill, a separator above and communicating with the mill, means for passing a stream of heated air through the mill and separator, ground material being carried in suspension in the air stream upwardly from the mill into the separator and sufficiently pulverized material being carried from the separator in the air stream while insufficiently pulverized material is rejected by the separator, means for collecting and withdrawing this rejected material comprising a rotating receptacle positioned in the path of the air stream intermediate the mill and separator and a scoop positioned to withdraw material collected on and thrown outwardly by the receptacle, and means for mixing water with the withdrawn material and returning the mixture for further treatment between the grinding elements, the water being evaporated and carried out by the heated air stream.

3. In combination, a mill comprising relatively moving grinding elements, means for feeding dry material to be ground into the mill, a centrifugal separator communicating with the mill and comprising a rotating element adapted to concentrate the coarser material near the peripheral wall of the separator, means for passing a stream of heated air through the mill and separator, ground material being carried from the mill in suspension in the air stream and subjected to a centrifugal separating operation in the separator whereby the material requiring further grinding is concentrated near the peripheral wall of the separator, means comprising a scoop for withdrawing the insufficiently pulverized material from the separator, and means for mixing water with this withdrawn material and returning the mixture to the mill for further grinding, the water being evaporated and carried out by the heated air stream.

4. In combination, a mill comprising relatively moving grinding elements, means for feeding dry material to be ground into the mill, a separator communicating with the mill, means for passing a stream of heated air through the mill and separator, ground material being carried in suspension in the air stream from the mill into the separator and sufficiently pulverized material being carried from the separator in the air stream while material requiring further grinding is rejected by the separator, means for selectively collecting and withdrawing different grades of material rejected from alternative positions in the separator and from the air stream intermediate the separator and mill, and means for mixing a temporary binding agent with the withdrawn material and returning the mixture to the mill for further grinding.

5. In combination, a mill comprising relatively moving grinding elements, means for feeding material to be ground into the mill, a separator communicating with the mill, means for passing a stream of heated air through the mill and separator, ground material being carried in suspension in the air stream from the mill into the separator and sufficiently pulverized material being carried from the separator in the air stream while material requiring further grinding is rejected by the separator, means for selectively collecting and withdrawing different grades of material rejected from alternative positions in the separator and from the air stream intermediate the separator and mill, and means for mixing water with the withdrawn material and returning the mixture to the mill for further grinding, the water being evaporated and carried out by the heated air stream.

6. In combination, a mill comprising relatively movable grinding elements, means for feeding into the mill dry material to be ground, a separator communicating with the mill and comprising a peripheral wall, an inner rotating element and a centrifugal separating zone above said element and enclosed in the peripheral wall, means for passing a stream of heated air through the mill and separator, ground material being carried in suspension in the air stream from the mill into the separator and sufficiently pulverized material being carried from the separator in the air stream, some of the material requiring further grinding being concentrated in the peripheral portion of the centrifugal separating zone, a conduit leading from the peripheral wall of the separating zone, an adjustable scoop member positioned in the wall at the entrance to the conduit and adapted to withdraw the insufficiently pulverized material from the air stream, a mixer into which the conduit leads, and means for feeding water into the mixer, the mixer delivering the mixture formed therein into the mill for further grinding, and the water being evaporated in the mill and carried out by the heated air stream.

7. The process of pulverizing material which consists in first introducing solid and substantially dry material into a mill through which is passed a heated air stream which carries ground material from the mill in suspension, removing from the air stream insufficiently pulverized material which requires further grinding, subsequently removing from the air stream the sufficiently pulverized material, mixing the first removed insufficiently pulverized material with a temporary binding agent and introducing this mixture into the mill for further grinding, and removing the binding agent.

8. The process of pulverizing material which consists in first introducing solid and substantially dry material into a mill through which is passed a heated air stream which carries ground material from the mill in suspension, removing from the air stream insufficiently pulverized material which requires further grinding, subsequently removing from the air stream the suffi-

ciently pulverized material, mixing the first removed insufficiently pulverized material with a temporary binding agent and introducing this mixture into the mill for further grinding, and removing the binding agent in suspension in the air stream.

9. The process of pulverizing material which consists in first introducing solid and substantially dry material into a mill through which is passed a heated air stream which carries ground material from the mill in suspension, removing from the air stream insufficiently pulverized material which requires further grinding, subsequently removing from the air stream the sufficiently pulverized material, mixing the first removed insufficiently pulverized material with a small quantity of water and introducing this coherent mixture into the mill for further grinding, the water being evaporated and removed by the heated air stream.

JOE CRITES.