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METHOD OF AND APPARATUS FOR FEEDING MATERIALS
TO DRUM TYPE CRUSHING AND GRINDING MILL

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2 Sheets-Sheet 1

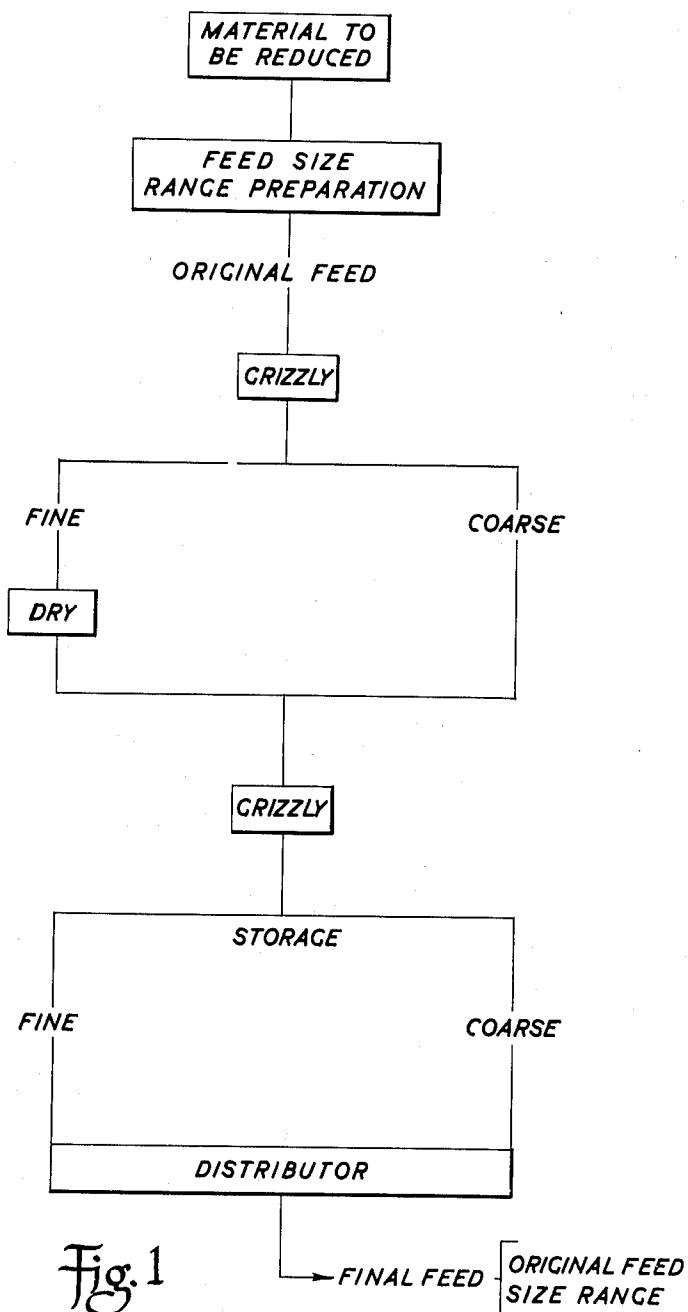


Fig. 1

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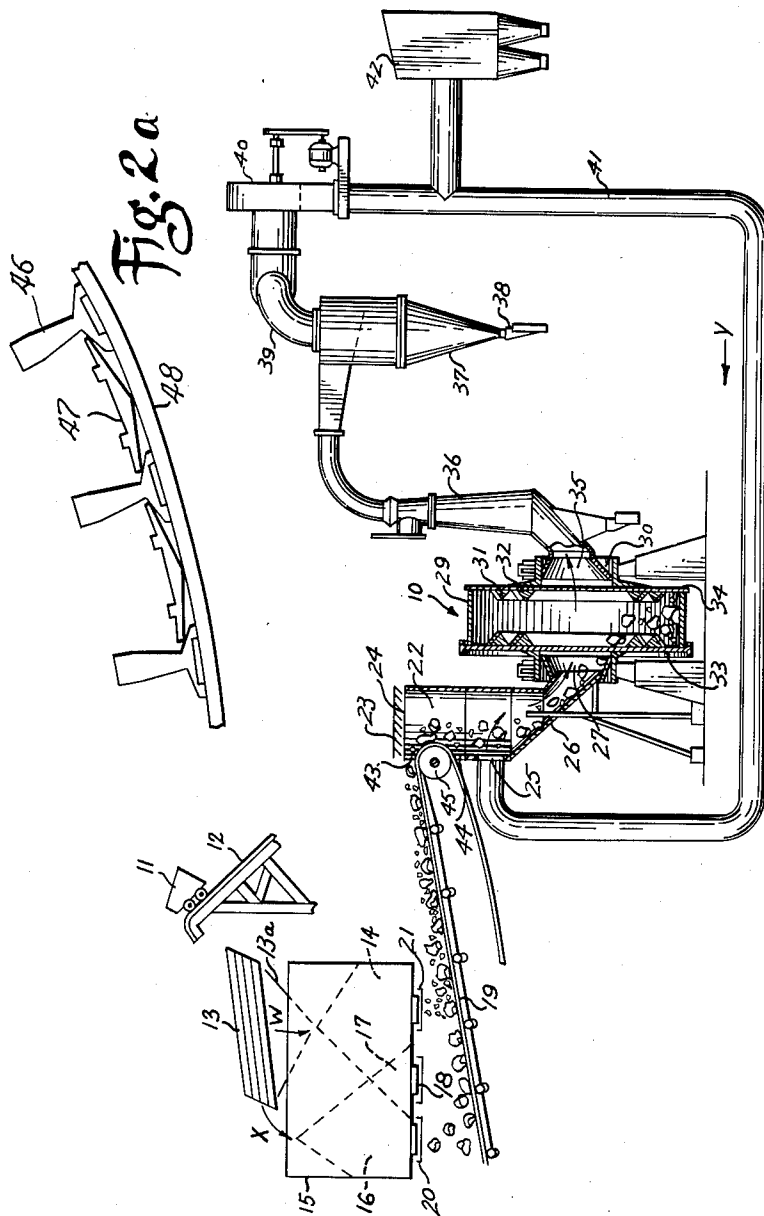
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METHOD OF AND APPARATUS FOR FEEDING MATERIALS TO DRUM TYPE CRUSHING AND GRINDING MILL

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10 Claims. (Cl. 241—24)

This invention relates to improved methods of and apparatus for size reduction of materials.

In my previous applications Serial No. 749,131, filed May 20, 1947, now U. S. Patent No. 2,555,171, and Serial No. 175,353, filed July 22, 1950, now abandoned in favor of U. S. Serial No. 315,470, filed October 18, 1952, now Patent No. 2,704,636, of which the present application forms a continuation-in-part, I disclosed a milling method in which material to be reduced is fed to a drum type of mill of a specific character which has a combined crushing and grinding action. The reduced material is drawn from the drum by means of an air stream passing through the rotary axis thereof, by which means a selected particle size range is entrained in accordance with the velocity of the air passing therethrough. The mills described in my said copending applications are characterized generally by a diameter-length ratio of at least 2:1 with highly up-standing transverse crusher bars spaced uniformly about the interior of the cylindrical periphery of the drum. The mills are further characterized by opposed annular liner or ring deflector members of, for example, frusto-conical configuration secured to the interior of the end walls of the drum concentric with but spaced radially outward from the inlet and outlet openings. Such mills may be designated as "combined dry crushing and grinding mills."

I have found that although such a system works very satisfactorily in accordance with the teachings of my prior disclosures, there are ways and means of considerably increasing the overall efficiency of operation.

Thus, in accordance with the present invention I provide a method and means for preparing the particular material to be reduced in the mill previous to entry of the same into the mill. Also I charge the material into the mill in a specific way. I have found that the general factors to be controlled are: segregation of feed during storage, volumetric ratio of coarse to fine, and moisture content of feed.

In prior practice there have been attempts to control the segregation factor during active feeding of the material into the mill. In all practical cases, however, it is necessary to store the material near the mill and in such storage, problems of segregation arise. Accordingly, storage bins have for many years been designed in accordance with design principles minimizing segregation during storage. Material has previously been drawn from such storage according to the requirements of the mill having regard to efficiency of the latter, but such system results in lack of balance in the storage system.

I have found that the problem of segregation during storage may be substantially obviated by adopting a very simple system of handling. Thus I first determine the feed required by the mill for its best efficiency. If, for example, the final feed to the mill should be comprised of, say, a maximum of 75% minus three inch material, then an original feed is prepared from the material to be reduced in such manner that the original feed comprises a minimum of 25% plus three inch material according to the instant example. The original feed is then separated

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into a relatively coarse part and a relatively fine part wherein the relatively coarse part comprises substantially the said minimum 25% plus three inch material.

In proceeding in this way I find that the problem of segregation during storage is substantially obviated since I may simply store these parts separately. When the parts are required for the final feed to the mill I merely distribute from storage coarse and fine material in proportion to the ratio of same in the original feed. In so doing I may accept segregation occurring in either of the parts of the original feed during storage of the latter but I have found this to be no practical limitation in practice. The specific manners of treatment and alternatives of the method herein are disclosed hereinafter in more detail.

Also in conjunction with the preparation of the original feed according to this invention and the storage of same, I may dry the material in a predetermined way such as by effecting drying of only the relatively fine part and thus effecting considerable saving while neglecting to dry the relatively coarse part. I have found that in preparing a final feed according to this invention for entry into a mill of the class defined in my prior applications the overall moisture content of the feed need only be controlled to a value of about 6% or less.

Having regard to the foregoing, it will be appreciated that the present invention relates to a method of reducing material to a desired particle size to deliver the latter as a product from a reducing mill requiring at least a predetermined percentage of coarse material in the feed thereof for efficient operation, and comprises the steps in combination of: preparing from the material an original feed having a predetermined percentage of a selected plus size of relatively coarse material adapted for efficient reduction in the mill and having a predetermined ratio of such relatively coarse material to the fine material thereof; then separating the original feed into relatively coarse and relatively fine parts, and delivering said coarse and fine parts to the mill substantially in the said ratio of coarse to fine of the original feed.

The foregoing and other objects of the invention will be apparent from a study of the following specification taken in conjunction with the accompanying drawings.

In the drawings:

Figure 1 is a flow sheet of the preparation of material for feed according to the invention.

Figure 2 is a diagrammatic illustration of a method and apparatus for reducing the feed material to a desired size of product and illustrating in particular a rotatable drum class mill of my preferred design such as disclosed in more detail in the said prior applications.

Fig. 2a is an enlarged cross-section of a portion of the mill periphery showing details of the crusher bars.

In a milling circuit according to my invention, I prepare the material to be reduced to provide a feed of desired characteristics. The type of reducing apparatus with which I am concerned herein is preferably that class which is in the form of a rotatable drum mill adapted to both crush and grind the material as disclosed in my prior applications and from which the desired size of material may be extracted by passing an air stream through the mill.

Referring to Figure 1, the preparation of the material to be reduced essentially begins with preparation of an original feed having a predetermined percentage of a selected plus size of material adapted for efficient reduction in the mill such as by passing the material through one or more crushing stages. In some cases the minus selected size particles may be further reduced at this stage of preparation of the original feed having regard to special metallurgical conditions in after-treatment past the mill. If the material is frozen, it may be thawed after passing

through the primary crusher, or the material may normally be wet whereby an initial wet feed is obtained.

Thus in the reducing operation carried out in the mill 10 of Figure 2, acceptable operating efficiency may be maintained up to a maximum of 75% minus three inch material. For such maximum I specify that the primary crusher or crushing stages prepare the feed for a minimum percentage of 25% plus three inch. However, in a mill of the class shown in Figure 2 the efficiency of operation may usually be maintained through a wide range of percentage of plus material of selected size, i. e. from 25% to 75% of plus three inch. There is thus opportunity for considerable flexibility of feed in ratios having less than 75% minus three inch according to this example. Also as previously indicated, there may be some cases where the minus three inch material should comprise for example substantially all minus two inch material with a negligible percentage between plus two and minus three. A case of this kind may arise where some special conditions must be met past the mill in a particular metallurgical process. Thus in a special case of this kind, the relatively fine part of minus three inch from the primary crusher in the preparation of the original feed may be passed through a secondary crusher to be delivered therefrom as, say, minus two inch to, therefore, form a feed of, say, a minimum of 25% plus three inch and a maximum of 75% minus two inch.

As illustrated in Figure 1, the original feed obtained is passed over a grizzly to distribute it into two parts of relatively fine and relatively coarse material. Preferably these parts range in size above and below a selected size material. Thus, the fine part may be substantially minus three inch material for the present illustration, and the coarse part substantially plus three inch material up to practical size limitations of handling and feeding such as about eighteen inches on the largest dimension.

In the flow sheet illustrated in Figure 1 the fine part may be wet, in which case it is dried in a suitable dryer such as a tube through which a conveyor passes, hot air being passed through the tube in a countercurrent direction (not shown). Any other known drying method may be employed. The drying is continued until the fine part attains a moisture content of less than about 6% after which the fine part is preferably combined with the coarse part and carried by a single conveyor to a grizzly onto which the fine and coarse material is dumped. At this point the dry original feed may be merely dumped into unconfined storage such as in the open to form two piles of relatively coarse and relatively fine material. Preferably the relatively coarse pile of material is comprised of the selected plus size range of material. Thereafter material is distributed from such unconfined storage to form a final feed having the same ratio of the plus selected size range to the minus selected size range as that occurring in the original feed. In handling such material to and from storage and to ensure the desired ratio of recombination of coarse and fine material for delivery of same to the mill, I may employ devices of well-known construction, adapted to control the volume ratio of material coming from a belt or hopper and check such volume ratio against the weight of material passing to and from storage. Volume control devices may also be employed in any specific application, but substantially retaining the original feed ratio in delivery from storage to the mill. Obviously the storage may be accomplished by previously used methods in which separate piles of material are stored in bins and from which material may be selected in a predetermined ratio. According to my method, however, such predetermined ratio is determined by the ratio occurring in the original feed. Moreover, I have found a method of increasing the effectiveness of storage in bins and retain my overall criterion of substantially neglecting segregation of material in each pile.

Thus in Figure 2, a suitable skip car 11 running on an

inclined track 12 may convey the dry fines and coarse material to the grizzly 13 through which the fine part of the material will fall to form a pile of fines 14 in the single bin 15. The coarse material falls off the end of the grizzly 13 to form a pile 16 of relatively coarse material. The bin 15 serves as a storage device and it will be observed that the piles 14 and 16 overlap at an intermediate region 17. The overlapping portion 17 constitutes a mixture of the material from the piles in the desired ratio and proportional to the original feed from the primary crusher. Thus I provide an opening in the bottom of the bin 15 directly below the overlapping portion 17 and having a feeder 18 thereon which may be of the electrical vibrator type actuated in known manner independently to cause material to be fed to the inclined conveyor 19. Also similar feeders 20 and 21 may be disposed below openings in the bin 15 directly below the piles 16 and 14. I may in some cases convey material from the feeders 20 and 21 separately to the mill and combine the material from such conveyors in the mill itself. The feeders 18, 20 and 21 are preferably of the adjustable volumetric type checked by weighing devices whereby to measure the feed from the bin and the piles therein according to the predetermined ratio of the original feed.

The bin 15 is of a particular design according to the invention herein contrary to prior practice requiring relatively deep bins to avoid the problem of segregation in a single pile of material. I merely provide a relatively large bin as indicated at 15 adapted to receive the piles of relatively coarse and relatively fine material 14 and 16 in side-by-side and exposed relationship relative to one another and accepting whatever segregation may take place in the piles. The location of the feeder 18 is of some importance in an arrangement of this kind because it is necessary to locate it in accordance with the natural angles of repose of the separate piles and the overlapping portion 17 therebetween. Alternatively the material for the piles may be fed into the bin in a predetermined way such as by moving the grizzly 13 so that the apices of the piles are located in the bin in predetermined manner in accordance with the angles of repose of the material therein. A further point of importance is that the relative volumes of the piles of material 14 and 16 are determined by the particle size distribution. Thus, a feed of 25% plus three inch material may involve a larger volume of this latter than the fines. For this reason, therefore, as illustrated in Figure 2, the grizzly 13 may have therebelow a fines chute 13a through which the fines pass in the direction of the arrow W to the fines pile 14, the latter in this case being shown as having a lesser angle of repose than the coarse pile 16. The grizzly is moved to direct the coarse particles by the path X whereby the piles of relatively coarse and fine material are of substantially the relative required volumes within the bin.

Thus the feeder 18 in the overlapping portion 17 is disposed closer in this case to the feeder 20 than to the other feeder 21. Such feeder 18 selects material from the overlapping portion 17 in accordance with the conditions imposed by the angle of repose of the material in each pile. It will be apparent, therefore, that where the feed so departs from a criterion of 25% plus three inch to thus change the volume relation between the relatively coarse and relatively fine material or else some other factor such as storing a different kind of material having different relative volume relationships, then the grizzly 13 and the chute 13a may be adjusted to requirements. The usual design procedure will be to locate the feeder 18 at a point between the feeders 20 and 21 according to the preferred size characteristics of the material being worked upon. Any change in sizing in the relatively coarse and relatively fine piles effecting the angle of repose thereof may thus be compensated for by adjusting the grizzly 13 and the chute 13a to move the apices of the respective piles to desired points and dispose the overlapping portion of the piles above the feeder 18.

Thus compensation may be made for differences in the angle of repose of the piles due to variations in their particle sizes. One further factor is that the lateral dimensions of the bin may still in some cases be proportioned in accordance with general bin design practice as hereinbefore indicated but in general this would be found to be an unnecessary refinement of design.

The feeders 20 and 21 may be employed as emergency feeders or as separate units. Usually such feeders will require adjustment every 24 hours so that the distribution therethrough is in proportion to the ratio of coarse and fine material fed into the bin 15. At this point it will be apparent in some cases that it may be desirable to feed the relatively coarse and relatively fine material separately to the bin 15 in which case the location of the piles 14 and 16 may be adjusted with more facility.

In Figure 2, material is shown falling from the feeders 20 and 21 to the conveyor 19 and passing into the enclosed chute 22 having an air entry control valve mechanism 23 thereon at the primary inlet opening 24. The feed material falls through the chute 22 past the secondary inlet opening 25 and then slides down the inclined wall 26 through the central opening 27 of the hollow trunion 28, which latter supports the drum structure 29 of the mill 10 in co-operation with a second hollow trunion 30.

It should be clearly appreciated that my method of feeding to the mill, although based on a criterion of, say, a minimum of 25% plus three inch material according to the example given herein, necessarily requires that the actual feed both in the original and final state should have present an amount greater than the given figure of 25% of the plus three inch material. Thus, for example, the actual original feed prepared, although necessarily having a minimum of 25% plus three inch for the necessary efficiency of the final reducing action in the mill, would be prepared for, say, a 30% volume of plus three inch material therein. The excess of selected plus size over the minimum requirement compensates for relative volumetric changes in the feed due to inefficiencies of separation for storage, and segregation occurring in the coarse pile of material during storage. Even under very severe conditions segregation in the relatively coarse pile will not cause the percentage of selected plus material in the final feed to fall below the minimum specified provided the original feed contains a sufficiently greater volume of the selected plus size than the minimum percentage required for efficient mill action. The type of segregation experienced in the storing of coarse material of this nature may only be of sufficient severity to reduce the amount of coarse material in the final feed during any unit time to a value of, say, 28%, rather than 30%. It is by reason of this approach to the problem that I am enabled to ignore segregation during storage.

It will be observed that the mill shown in Figure 2 has annular liners 31 and 32 on the side walls 33 and 34 thereof similar to those disclosed in my prior application, Serial No. 175,353, filed July 22, 1950. The mill also has highly upstanding transverse crusher bars spaced uniformly about the interior of the cylindrical periphery of the drum, such as illustrated by Fig. 2a which is an enlargement of a partial end view of the drum showing in detail crusher bars 46 held against the periphery 48 by liner elements 47 secured between adjacent crusher bars.

The control of the moisture in the material fed to the mill is particularly important with respect to the rate of delivery of reduced material from the mill by reason of the efficiency of the crushing and grinding action therein. Whereas in standard dry grinding practice a moisture content in the feed of up to about 2% may be tolerated without affecting efficiency of such prior grinding units, I have found that, where a mill of the combined crushing and grinding class such as that of my own design referred to is employed, a higher moisture content in the feed may be tolerated before the efficiency of the

mill drops off. Some of the experimental work is reported in a paper entitled "Recent Investigations Into The Beneficiation of Canadian Gypsum," Department of Mines and Resources Memorandum, of December 1950, reporting permissible moisture content in the feed up to 3% in the reduction of Gypsum. Present dry grinding practice on this material is to dry to a maximum moisture content of 1% before final reduction. The permissible moisture content depends upon the type of material being reduced and the fineness in grind required. Thus, in the reduction of sandstone, satisfactory efficiency was obtained up to a moisture content of 5.8%. In general the efficiency drops off markedly above a moisture content of about 6%.

The essence of my milling system disclosed herein is that the material to be reduced, before entering into any separation thereof for re-combining to predetermined feed ratios, is first prepared to provide an original feed of desired size ratio having a percentage of selected plus size in excess of that minimum required for efficient mill action. In general, therefore, I treat the material in a preliminary manner by crushing to a desired percentage of coarse material of a selected plus size range, whether dry, wet or frozen. If the material is wet or is required to be thawed upon crushing, then it is separated into relatively coarse and fine parts in which normally the fine part only is dried to a moisture content of less than about 6%. If the feed material is in the first instance relatively dry, requiring no separate drying of the fines in accordance with the teachings herein, then it is merely passed from the crushing stage to a single storage bin wherein it is separated into relatively coarse and relatively fine piles of material. In particular, however, I distribute the material from storage in a manner proportional to the ratio of coarse to fine in the original feed as obtained from, say, the primary crusher, and in this way avoid unbalance in storage as between coarse and fine piles.

It is intended that this disclosure should not be construed in any limiting sense particularly as to the preferred type of reducing mill specified herein except as may be defined by the scope of the following claims.

What I claim as my invention is:

1. A method of feeding material to a combined dry crushing and grinding mill of the type comprising a drum having a diameter length ratio of at least 2:1, highly upstanding transverse crusher bars spaced uniformly about the interior of the cylindrical periphery thereof and opposed annular liner deflector members secured to the interior of the end walls, said method comprising preparing from the material an original feed having at least a predetermined minimum percentage of relatively coarse material of a selected plus size; separating said original feed into a relatively fine part and a relatively coarse part containing substantially all the material of said selected plus size; handling each of said parts separately until substantially immediately prior to their delivery to the mill; and delivering said parts to the mill substantially in the same ratio as they are present in said original feed.

2. A method as defined in claim 1 wherein the handling separately of said two parts includes conveying and storage of each of said two parts.

3. A method as defined in claim 1, wherein the handling separately of said two parts consists in conveying said relatively coarse part to storage; drying said relatively fine part to a moisture content below 6% and conveying it to storage; feeding said parts from storage in substantially the same proportion as they are present in the original feed; and delivering the material thus fed from storage to the mill.

4. A method as defined in claim 1 wherein the selected plus size of material is plus 3".

5. A method as defined in claim 1 wherein the predetermined minimum percentage of relatively coarse material is 25%.

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6. A method as defined in claim 1 wherein said original feed is prepared by crushing said material.

7. A method as defined in claim 1 wherein the original feed contains from 25% to 75% of plus 3" size material.

8. In combination with a combined dry crushing and grinding mill of the type comprising a drum having a diameter length ratio of at least 2:1 with highly upstanding transverse crusher bars spaced uniformly about the interior of the cylindrical periphery thereof, and opposed annular liner deflector members secured to the interior of the end walls, feeding means comprising; crushing means arranged to produce a crushed original feed containing at least about 25% of substantially plus three inch material; means for separating said original feed into one part containing the material above said percentage and another part containing the remainder of said material; means for separately handling said two parts and storing the same separately adjacent said mill; means for recombining said two parts in the proportions in which they were present in said crushed original feed and means for feeding the thus recombined material to the mill.

9. Apparatus as defined in claim 8 comprising proportioning feeders arranged to feed said parts from separate storage in the proportions in which they were present in said crushed original feed and conveyor means arranged to convey the thus fed material and discharge the latter into said mill.

10. Apparatus as defined in claim 8 comprising drying means for said fine part arranged between the means for separating said initial feed into two parts and the separate storage means for said fine part.

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