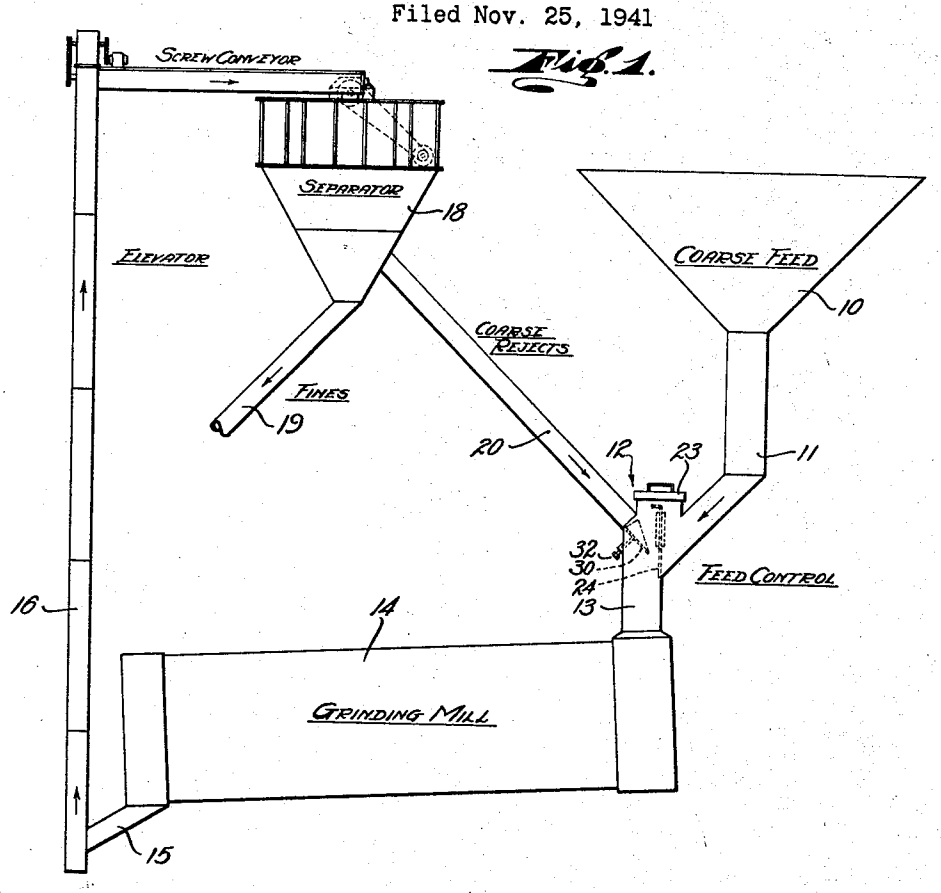
May 4, 1943. W. C. HANNA ET AL 2,318,306

FEED SYSTEM FOR GRINDING MILLS

Filed Nov. 25, 1941

Fig. 1.



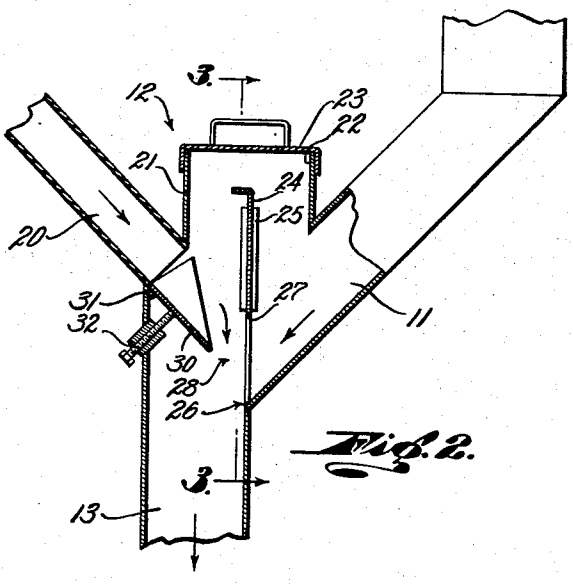


Fig. 2.

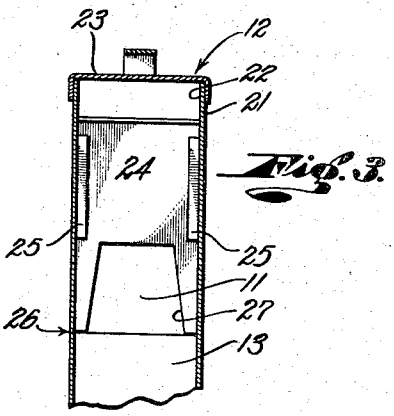


Fig. 3.

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FEED SYSTEM FOR GRINDING MILLS

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15 Claims. (Cl. 83—44)

This invention has to do generally with feed control for grinding mills in the operation of which solid granular or lumpy material is fed for grinding, the ground material is separated into relatively fine and coarse particles, and the latter circulated for regrinding in the mill. While the invention is broadly applicable to various dry grinding operations of this general character, it has been applied with outstanding success in grinding Portland cement materials, including raw (argillaceous and calcareous) materials as well as the cement clinker. Accordingly, the invention will be described typically with reference to grinding operations in the manufacture of Portland cement.

Ordinarily, and as herein contemplated, a grinding mill, for example a rotary ball mill of given size and ball load, and rotating at constant speed, will apply to the material undergoing grinding what may be termed constant grinding energy. It is of course desirable in most instances that the fineness of the ground product be as constantly uniform as possible, and theoretically such uniformity would exist where the material fed to the mill has uniform size, composition, and rate of delivery. In practice, however, any or all of these conditions are subject to variation, and consequently it becomes necessary to maintain the grinding operation under a control tending to prevent or minimize changes in the fineness of the product. Since it is impossible or impractical to obtain this result by varying the composition or size of the material being ground, the customary practice has been to regulate the rate at which the material is fed to the mill.

Heretofore, this has been done manually or by automatic feed controls, the latter involving considerable expense and mechanical complications, and oftentimes failing to maintain the desired accuracy of control over the fineness of the final product. The primary object of this invention is to provide an automatic and exceptionally accurate feed control of such extreme simplicity, both mechanically and in its operation, that the usual feed control mechanisms may be entirely dispensed with in favor of a simple arrangement for merging the mill feed and recirculated particle streams under conditions such that the former is controlled by the latter and the mill is caused to deliver a product of uniform fineness.

The invention is predicated upon the observation that an increase in the recirculation rate of the separated coarse particles results from the mill "grinding coarser," and the discovery that the rate at which the raw material is fed to the mill can be made to vary in inverse proportion to the quantity of recirculated particles, by simple and direct impingement of the two streams. Thus, the entire mechanical requirements of the system may be satisfied merely by merging the streams in a manner such that a decrease in the rate of recirculation of the separated coarse particles will cause a compensating increase in the rate of the mill feed, and conversely as the recirculated particle flow increases.

According to the illustrative system hereinafter described in detail, the grinding mill receives a continuous gravity feed of the coarse material to be ground, and which may consist of Portland cement raw materials, or Portland cement clinker as it is produced from the calcining kiln. From the grinding mill, the material is taken for separation, as by entrainment in an air stream, into relatively fine particles which constitute the ground product, and relatively coarse particles or rejects which are recirculated in a stream of air to the main feed stream gravitating into the mill. Preferably the latter stream is caused to pass through an opening of particular shape, as later described, and the reject stream from the separator is projected against the main feed stream at the outlet side of the opening, all in a manner whereby the main feed rate is subject to variation or control in inverse relation to the quantity rate of recirculation of the coarse particles rejected by the separator.

The invention contemplates various particular features such as the use of interchangeable control gates having different size openings to vary correspondingly the rate at which the main stream of coarse material is fed to the mill, and the provision of means whereby the angle of impingement of the recirculated and main feed streams may be varied to sensitize or otherwise desirably affect the control. All such features, as well as the broader aspects and objects of the invention, will be understood to better advantage from the detailed description to follow. Reference is had throughout the description to the accompanying drawing, in which:

Fig. 1 illustrates diagrammatically a typical feed control system embodying the invention;

Fig. 2 is an enlarged sectional view taken at the feed gate and juncture of the streams flowing to the mill; and

Fig. 3 is a fragmentary section taken on line 3—3 of Fig. 2.

Referring first to Fig. 1, the coarse material to be ground may be fed by gravity from hopper or bin 10 through passage 11 to the feed control,

generally indicated at 12, and thence through passage 13 into the conventionally illustrated grinding mill 14. The latter of course may be of any suitable type and construction, operating to apply to the material flowing through the mill, constant or uniform grinding energy. Typically, the grinding may be accomplished by a ball mill rotating at constant speed.

The ground material is discharged from the mill through outlet passage 15 and then taken for separation into relatively fine and coarse particles. As illustrative, the grinding mill discharge may be transferred within conduit 16 by a conveyor or other suitable means and introduced into a separator 18 (for example, the commonly used Sturtevant rotary blower type separator within which air flow is generated for classification of the particles to be separated), from the bottom of which the fines, i. e. the materials that are ground to the desired fineness, are withdrawn through line 19. Relatively coarse particles which have not been reduced in the grinding mill to the desired fineness, are rejected by the separator and recirculated in an air stream developed by the separator, through conduit 20 to the feed control 12, wherein the coarse rejects are combined with the main feed stream, as will now appear.

Referring to Fig. 2, the juncture of passages 11, 13, and 20 is formed by a box 21 accessible through top opening 22 normally closed by a cover 23. The box 21 contains a vertically positioned feed gate 24 extending transversely the distance between the side walls of the box and confined between suitable guides 25. The lower end of the control gate rests at 26 on the bottom surface of the inclined feed passage 11.

As best illustrated in Fig. 3, the main feed stream discharges from passage 11 into the vertical passage 13, through an opening 27 in the feed gate, this opening being smaller than the cross-sectional area of passage 11 and therefore restricting to some extent the passage of material at the location of the gate. The degree of restriction is variable by substituting feed gates having different size openings. After considerable experimentation and test operations, best results with respect to uniformity of control have been obtained by using a form of opening 27 of downwardly increasing width, so that somewhat greater restriction is given to the material passing through the upper portion of the opening and in the general location of the impingement of the recirculated reject stream. It is preferred to form the opening 27 as as isosceles trapezoid, the proportions of which with relation to passage 11 are substantially as illustrated in Fig. 3.

Referring again to Fig. 2, passages 20 and 11 are arranged so that their longitudinal axes, or the lines of flow of the materials through them, are disposed at substantially a 90 degree angle. Passage 20, however, is relatively elevated, so that the material discharged therefrom impinges at 28 against the main feed stream more directly opposite the central portion of the feed gate opening 27. This angle of impingement may be varied by changing the angularity of the outlet end of passage 20. For example, the discharge end of the passage may be formed as a chute 30 pivotally supported at 31 and adjustable about the pivot to vary its angularity, by set screw 32 or other suitable means.

Being projected in the air stream at considerable velocity at 28 against the main feed stream, the separator rejects strike the main feed stream with sufficient force to control, at least within necessary limits, the rate at which the material is discharged through opening 27. Thus as the percentage of rejects increases, the increased force of the projected reject stream exerts a retarding effect upon the rate at which the main feed stream passes through opening 27 to the grinding mill, and conversely as the percentage of rejects decreases and the force of the projected reject particles against the main feed stream diminishes. Consequently, if the mill for any reason starts to "grind coarse," the immediate result will be a decrease in the rate of mill feed, continuing until the ground material again reaches a predetermined degree of fineness. And where such desired fineness is being exceeded, the consequent increase in the mill feed rate promptly consumes the excess grinding energy of the mill, to restore the proper fineness balance.

We claim:

1. In the operation of a grinding mill to which a stream of solid material flows for grinding and from which the ground material is taken for separation into relatively fine and coarse particles; the method that includes projecting a stream of the separated coarse particles in varying quantities against said stream of solid material in a direction and at a velocity such that the kinetic energy of said particles variably restrains the flow of said solid material to the mill, thereby causing the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being projected against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

2. In the operation of a grinding mill to which a stream of solid material flows for grinding and from which the ground material is taken for separation into relatively fine and coarse particles; the method that includes projecting a stream comprising substantially all of the separated coarse particles in varying quantities against said stream of solid material in a direction and at a velocity such that the kinetic energy of said particles variably restrains the flow of said solid material to the mill, thereby causing the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being projected against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

3. In the operation of a grinding mill to which a stream of solid material is fed for grinding and from which the ground material is taken for separation into relatively fine and coarse particles; the method that includes maintaining a gravity feed of a downwardly flowing stream of said solid material into the mill, and controlling the rate of said feed by projecting a stream of the separated coarse particles in varying quantities against said stream of solid material in a direction and at a velocity such that the kinetic energy of said particles variably restrains the flow of said solid material to the mill, thereby causing the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being projected against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

4. In the operation of a grinding mill to which a stream of solid material flows for grinding and

from which the ground material is taken for separation into relatively fine and coarse particles; the method that includes projecting a flow of air carrying a stream of the separated coarse particles in varying quantities against said stream of solid material in a direction and at a velocity such that the kinetic energy of said particles variably restrains the flow of said solid material to the mill, thereby causing the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being projected against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

5. In the operation of a grinding mill to which a stream of solid material is fed for grinding and from which the ground material is taken for separation into relatively fine and coarse particles; the method that includes maintaining substantial constancy in the size of said fine particles by projecting a stream of the separated coarse particles in varying quantities downwardly and angularly against a downflowing stream of said solid material at an angle of contact therewith and at a velocity such that the changing kinetic energy of said particles causes the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being projected against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

6. In the operation of a grinding mill to which a stream of solid material is fed for grinding and from which the ground material is taken for separation into relatively fine and coarse particles; the method that includes maintaining a stream of said solid material flowing by gravity to the mill through a passage and then through an opening of smaller size than said passage, and controlling the rate of said feed by projecting at the discharge side of said opening a stream of the separated coarse particles in varying quantities against said solid material flowing through the opening at an angle of contact and at a velocity such that the kinetic energy of said particles variably restrains the flow of solid material through said opening, thereby causing the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being projected against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

7. In the operation of a grinding mill to which a stream of solid material is fed for grinding and from which the ground material is taken for separation into relatively fine and coarse particles; the method that includes maintaining a stream of said solid material flowing by gravity to the mill through a passage and then through an opening of smaller size than said passage, and controlling the rate of said feed by projecting at the discharge side of said opening a flow of air carrying a stream of the separated coarse particles in varying quantities downwardly against the stream of solid material flowing through the opening at an angle of contact therewith and at a velocity such that the kinetic energy of said particles variably restrains the flow of said solid material to the mill, and the rate at which said material is fed to the mill is caused to decrease as the quantity of separated coarse particles being projected against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

8. In the operation of a grinding mill to which a stream of solid material is fed for grinding and from which the ground material is taken for separation into relatively fine and coarse particles; the method that includes maintaining a stream of said solid material flowing by gravity to the mill through an opening of downwardly increasing width and of smaller size than said passage, and controlling the rate of said feed by projecting at the discharge side of said opening a stream of the separated coarse particles in varying quantities against said solid material flowing through the opening at an angle of contact and at a velocity such that the kinetic energy of said particles variably restrains the flow of solid material through said opening, thereby causing the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being projected against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

9. In the operation of a rotary grinding mill applying substantially constant grinding energy to solid feed material being ground; the method that includes withdrawing the ground material from the mill and separating it into relaitvely fine and coarse particles, and directing together and then into the mill, downwardly convergent separate streams of said solid feed material and varying quantities of the separated coarse particles, said streams converging at an angle of substantially 90 degrees and the stream of separated coarse particles being projected against the feed material stream at a velocity such that the kinetic energy of said particles variably restrains the flow of said feed material to the mill, and the rate of flow of feed material into the mill increases and decreases, respectively, as the quantity of separated coarse particles directed against the feed material stream decreases and increases.

10. The combination comprising a grinding mill, means for feeding a stream of solid material for grinding in the mill, means for separating the ground material into relatively fine and coarse particles, and a conduit for directing a stream of varying quantities of the separated coarse particles against said stream of solid material, said conduit being positioned angularly relative to said feeding means so that the kinetic energy of said particles variably restrains the flow of said material to the mill and causes the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being directed against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

11. The combination comprising a grinding mill, means for feeding by gravity a downwardly flowing stream of solid material for grinding in the mill, means for separating the ground material into relatively fine and coarse particles, and a conduit arranged to project a downwardly flowing stream of varying quantities of the separated coarse particles against said stream of solid material at an angle of contact such that the kinetic energy of the particles variably restrains the flow of said material and causes the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being directed against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

12. The combination comprising a rotary grinding mill, means forming a passage through

which a stream of solid material flows downwardly by gravity for grinding in the mill, said passage containing a restricted opening through which said material flows, means for separating the ground material into relatively fine and coarse particles, and means for directing a stream of varying quantities of the coarse particles downwardly and angularly against the material flowing through said opening so that the kinetic energy of the particles variably restrains the flow of said material and causes the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being directed against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

13. The combination comprising a rotary grinding mill, means forming a downwardly inclined passage through which a stream of solid material flows by gravity for grinding in the mill, a vertically disposed wall in said passage containing an opening restricting the passage and through which said material flows, said opening having downwardly increasing width, means for separating the ground material into relatively fine and coarse particles and means for directing a stream of varying quantities of the coarse particles downwardly and angularly against the material flowing through said opening so that the kinetic energy of the particles variably restrains the flow of said material and causes the rate at which said material is fed to the mill to decrease as the quantity of separated coarse particles being directed against said stream of material increases, and to increase as said quantity of the separated coarse particles decreases.

14. The combination comprising a grinding mill, means forming a pair of downwardly inclined passages converging to a locus of intersection communicating with said mill, means for maintaining a stream of solid feed material to be ground in a state of gravity flow downwardly through one of said passages into the mill, means for withdrawing ground material from the mill and for separating the withdrawn material into relatively fine and coarse particles, means for passing a stream of varying quantities of the separated coarse particles downwardly through the other of said passages, and means for impinging said stream of coarse particles against said stream of solid feed material at said locus of intersection of the passages so that the kinetic energy of the particles variably restrains the flow of said material and causes the rate at which said feed material is fed to the mill to decrease as the quantity of separated coarse particles being directed against said stream of feed material increases, and to increase as said quantity of the separated coarse particles decreases.

15. The combination comprising a grinding mill, means forming a pair of downwardly inclined passages converging to a locus of intersection communicating with said mill, means for maintaining a stream of solid feed material to be ground in a state of gravity flow downwardly through one of said passages into the mill, means for withdrawing ground material from the mill and for separating the withdrawn material into relatively fine and coarse particles, means for passing a stream of varying quantities of the separated coarse particles downwardly through the other of said passages, and means at said locus of intersection of the passages causing the rate at which said feed material is fed to the mill to decrease as the quantity of separated coarse particles being directed against said stream of feed material increases, and to increase as said quantity of the separated coarse particles decreases, the last mentioned means comprising a vertically disposed wall at said locus of intersection and containing an opening through which said feed material flows, and means for directing said stream of separated coarse particles downwardly against the material passing through said opening and at an angle such that the kinetic energy of said particles variably restrains the flow of solid material to the mill.

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