FIP7900 OR 2,232,696 Search Room

Feb. 25, 1941. T. EARLE 2,232,696

METHOD FOR DETACHING AND CLEANING CONSTITUENT PARTICLES OF NATURALLY GRANULAR MATERIAL

Filed July 11, 1938 2 Sheets-Sheet 1

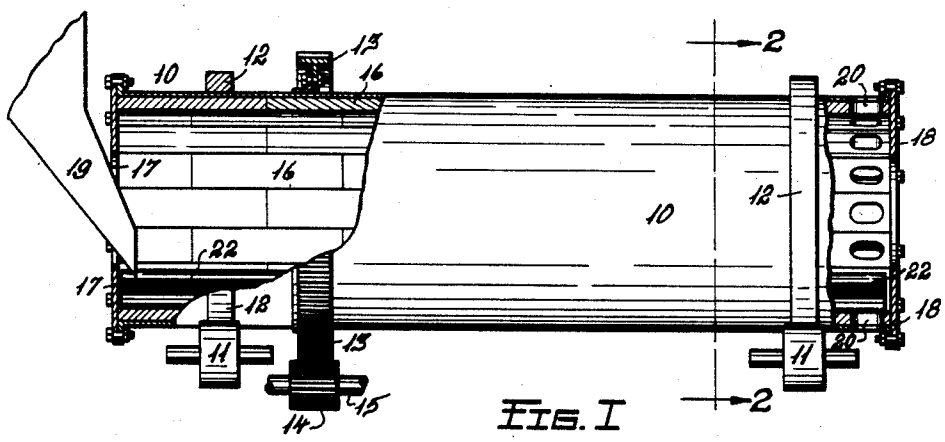



FIG. I

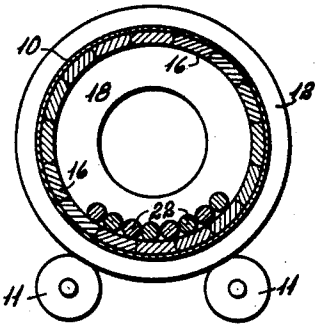



FIG. 2

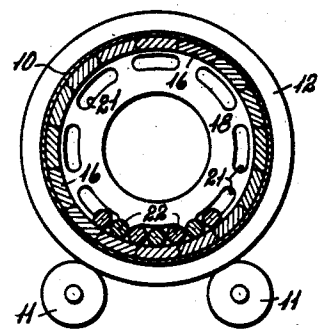



FIG. 3

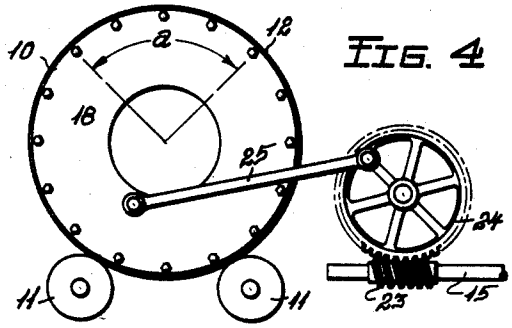



FIG. 4

INVENTOR
THEODORE EARLE
BY Howard G. Sweet
ATTORNEY

Feb. 25, 1941. T. EARLE 2,232,696

METHOD FOR DETACHING AND CLEANING CONSTITUENT PARTICLES OF NATURALLY GRANULAR MATERIAL

Filed July 11, 1938 2 Sheets-Sheet 2

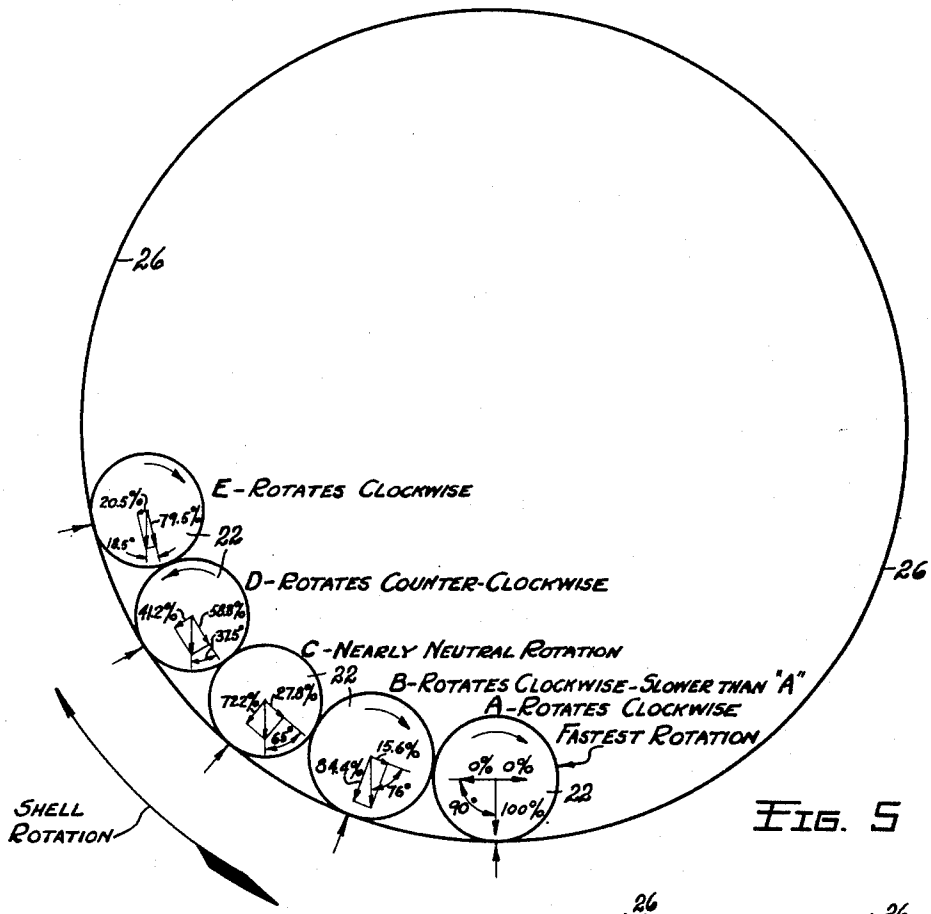



FIG. 5

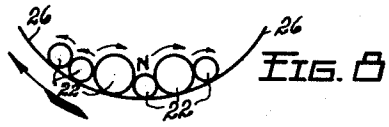



FIG. 8

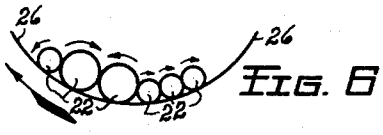



FIG. 6

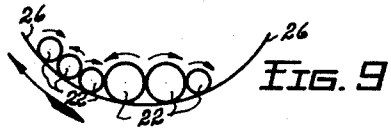



FIG. 9

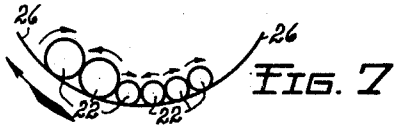



FIG. 7

INVENTOR
THEODORE EARLE
BY Homer L. Sweet
ATTORNEY

241. SOLID MATERIAL COMMINUTION OR DISINTEGRATION
14

Search Room

Patented Feb. 25, 1941

2,232,696

# UNITED STATES PATENT OFFICE

2,232,696

## METHOD FOR DETACHING AND CLEANING CONSTITUENT PARTICLES OF NATURALLY GRANULAR MATERIAL

Theodore Earle, Pacific Palisades, Calif.

Application July 11, 1938, Serial No. 218,530

2 Claims. (Cl. 83—94)

This invention is concerned with the treatment of naturally granular materials, such as sands, sandstones, friable ores and minerals, and the like, for disintegration of such material into its constituent particles or grains without destruction thereof, and has as an object to provide an improved method for freeing the natural constituent particles of friable granular material from their natural binder and from each other without excessive fracture or splintering of such particles.

A further object of the invention is to provide an improved method for the non-destructive detachment of constituent particles in granular material which is simultaneously operable to free the detached particles from coatings of their natural binding agent without excessive comminution and destruction of the natural particles constituting the material and binder.

A further object of the invention is to provide an improved method for the treatment of naturally granular material whereby the constituent natural particles of such material as well as of the binding agent associated therewith may be detached one from another and cleaned for subsequent separate recovery in substantially their natural form without excessive comminution and destruction of such individual particles.

A further object of the invention is to provide an improved method for the non-destructive disintegration of naturally granular material to its constituent particles, whereby such material is cleaned and treated in a manner which facilitates subsequent clean separation and recovery of certain of the constituent particles through froth flotation.

A further object of the invention is to indicate, generally, typical means and structural associations whereby the improved method of non-destructive disintegration of naturally granular material may be advantageously practiced to attainment of the objects above set forth.

My invention consists in the nature, combination, and sequence of steps constituting my improved method, as hereinafter set forth, and in the operative association of means and typical apparatus whereby the improved method is given practical effect, as hereinafter described, all as pointed out in my claims and illustrated by the accompanying drawings, in which—

Figure 1 is an elevation, partly in section, of conventionalized apparatus typifying a construction and arrangement of elements whereby the improved method may be practiced. Figure 2 is a cross section taken on the indicated line 2—2 of Figure 1. Figure 3 is a view similar to Figure 2 illustrating a modified construction of the apparatus shown in Figures 1 and 2. Figure 4 is an end elevation illustrating an alternative arrangement of means constituting apparatus through which the improved method may be effectively practiced. Figure 5 is a diagrammatic representation of cooperating elements constituting an apparatus of the type shown in Figure 1 and illustrating the cooperative relationship of said elements in terms of their relative action and forces. Figures 6, 7, 8, and 9, are diagrammatic representations of alternative arrangements of the elements shown in Figure 5 and illustrate variation in the relative action had between such elements resulting from variation in the relative arrangement of said elements.

In the preparation and treatment of various materials, notably sands, sandstones, naturally friable ores and minerals, and other like naturally granular and loosely cemented combinations of matter, for commercial use, it is frequently of extreme importance to effect detachment of the constituent material particles from each other and from the cementing or binding agent with which they are associated without crushing, grinding, splintering, or fracturing of the individual material particles, as well as to clean the surfaces of such particles from adhering matter to free such surfaces for characteristic reaction in subsequent separatory processes. In certain instances, it is the separate recovery of the naturally granular material, such as silica grains, which is sought, while in other instances the separate recovery of the cementing agent or binding material is desirable, but in either event a thorough reduction of the material to the form of completely detached, thoroughly cleaned, undamaged constituent grains or particles is a prerequisite to a clean and efficient separation of the one from the other, particularly when the actual separation and separate recovery is to be had through froth flotation methods, and the instant invention is concerned with an improved method whereby non-destructive detachment and surface cleaning of the particles constituting naturally granular material may be efficiently accomplished. While the improved method is particularly applicable to natural ores, minerals and the like, it may be employed to advantage in the detachment of other artificially or naturally combined materials in exactly the same manner as is hereinafter set forth with respect to ores and

minerals, the relative action of the typical means employed to develop the operative principle of the method being available to rub or scrub other materials to a reduction thereof to their constituent elements or particles.

The improved method consists primarily in subjecting the material to be cleaned and disintegrated to a rubbing and scrubbing action and to pressures sufficient to detach the various particles of the material from each other, all in the absence of impact effect tending to crush, splinter, or fracture such particles, and may be given practical effect through various specific constructions and arrangements of apparatus functionally equivalent with that typified by the drawings and hereinafter described.

The apparatus shown in Figures 1, 2, and 3 of the drawings approximates a conventional rod mill of the type commonly employed for the comminution of ores and minerals, and is shown as comprising an elongated, cylindrical, hollow drum or shell 10 suitably supported for rotation about its horizontally-disposed axis on paired rollers 11 suitably arranged and spaced to engage in drum-supporting relation with annular tracks 12 fixedly encircling said drum. A ring gear 13 is suitably fixed to the drum 10 in meshing relation with a pinion 14 which is operatively connected through a shaft 15 with any suitable source of power to the end that rotation of the shaft 15 may act through the pinion 14 and gear 13 to rotate the drum 10 in such direction and at such speed as may be desirable. The interior of the drum 10 is preferably lined and completely covered by sectional wear plates 16 removably and replaceably secured to the drum, as is common practice in rod mills, and the opposite ends of said drum are substantially closed by means of end plates 17 and 18 removably secured to and in axially-perpendicular relation with said drum. The plate 17 is suitably arranged to permit the feeding of material to be treated therethrough and into the interior of the drum 10, said plate being shown as formed with a central aperture wherethrough may extend the discharge end of a gravity chute 19 or equivalent structure thus disposed to deliver material within the drum 10 and adjacent the end plate 17. The closure plate 18 at the discharge end of the drum 10 may be formed with a central aperture wherethrough discharge may occur to limit the depth of material retained within said drum, in which event continuous discharge of treated material from said drum may be accommodated through escape ports 20 spaced circumferentially about and opening radially through the drum 10 and wear plates 16 adjacent said closure plate 18, or said plate 18 may be formed with circumferentially-spaced, arcuate slot openings 21 disposed in a common orbit adjacent the inner surface of the wear plates 16 for discharge of material outwardly of the drum 10, as is indicated in Figure 3. The drum 10 is adapted to contain and cooperate with a plurality of straight, cylindrical rods 22 of a length slightly less than the interior length of said drum between the end plates 17 and 18, and of such diameters and weights as may be best adapted for the desired treatment of given materials. The number of rods 22 associated with a given drum 10 may vary somewhat in the treatment of various materials by the improved method, but in no case should the number of such rods be so great as to permit cascading of the rods when the drum 10 is rotated or rolling or tumbling of some of such rods over and above the others. Naturally, since the function of the rods 22 has been set forth as a separation and cleaning of the constituent granular particles without splintering or crushing thereof, the weights of said rods must be adjusted and maintained below that minimum which would act to crush the granular particles as the individual rods roll or slide thereover, such weight consequently being a variable determined by the character of the specific material to be treated. The rods 22 are held against axial displacement from the drum 10 by means of the end plates 17 and 18 and are adapted to lie in contacting, parallel juxtaposition on and against the lower inner surface of the drum 10, or wear plates 16, in parallel relation with the drum axis. While eight rods 22 of uniform diameter are illustrated in Figures 2 and 3, such showing is in no sense limitative and is indicative only of a typical arrangement wherein the relative size and number of such rods may be varied as conditions and circumstances warrant.

The apparatus illustrated in Figure 4 differs from that previously described only in that the drum 10 is arranged for oscillation rather than rotation, the shaft 15 of Figure 4 carrying a worm 23 in meshing relation with a worm gear 24 which is in turn connected through a pitman 25 with the drum assembly so that rotation of the gear 24 acts to oscillate the drum assembly through the angle indicated at $a$. The showing of Figure 4 is but typical of drum mounting and actuating means operable to effect angular oscillation of the drum assembly through an arc of the desired magnitude, and is but representative of various structurally specific arrangements operable to the same end.

Practical tests have demonstrated that a relatively slow rotation of the drum 10 containing rods 22, in such number as will permit direct contact of each of said rods with the interior of the drum without any cascading effect of the rods, is productive of variation in the direction of rotation of the rods 22, as illustrated in the diagrams shown in Figures 5 to 9.

In Figure 5, two relatively larger rods 22 are shown associated with three relatively smaller rods 22 in operative relation within a cylindrical drum and in trailing relation in the direction of drum rotation with said relatively smaller rods. The orbit of rotation of the inner surface of the drum is indicated by the circle 26, the direction of rotation being as indicated by the arrow, the larger rods 22 are designated A and B, and the smaller rods are indicated C, D, and E. In the arrangement shown, it is found that a moderate rotation of the drum tends to position the five rods 22 in substantially the relationship shown in the diagram, the rod A assuming a position almost vertically beneath the center of the drum, and the remaining rods aligning in peripheral contact with the drum surface and with each other in successive leading relation in the direction of drum rotation with and ahead of the rod A. When so disposed, the rod A rests on the lowermost point of the drum surface with its weight acting radially of the rod and drum against said drum interior, so that rotation of said drum acts to rotate the rod A and imparts to the latter a peripheral speed equal to and in the same direction as the

OR DISINTEGRATION

14

Search Room



peripheral travel of the contacting drum surface, particles of material engaged between the adjacent surfaces of the rod A and drum interior being hence subjected to a smooth rolling action productive of a moderate crushing or separating effect deriving from the weight of said rod and hence insufficient to splinter, crack, or crush such material in any destructive sense. With the rod B in leading relation in the direction of drum rotation with and in contacting engagement against the rod A, the gravity pull on said rod B is resolved into two components, one of which, representing the major portion of the rod weight, acts radially of the drum to hold said rod against the inner drum surface while the other component tends to urge the rod B against the rod A. The major gravity component acting to hold the rod B against the drum interior is productive of a frictional engagement between said rod and drum which tends to rotate the rod B in the same direction as and at a peripheral speed corresponding with that of the interior drum surface, which rotative tendency is resisted by the frictional drag of said rod B against the rod A as well as by a frictional drag of the rod C which bears against the other side of the rod B, both of which resistances react to slow down or retard the speed of rotation of the rod B while being insufficient in amount to overcome the direction of rotation imparted to said rod through its engagement with the drum interior, the net result being that the rod B rotates in the same direction as but at a speed relatively less than that of the rod A. Material engaging between the rod B and the adjacent drum surface is thus subjected to a rubbing as well as a rolling action which tends to urge the particles of material apart and also rubs or scrubs the particle surfaces for cleaning effect, while material passing between the rods A and B is likewise subjected to a combined rolling and rubbing action resulting from the speed differential of said rods. In similar manner, the weight of the rod C is resolved into two components which urge said rod against the drum interior and into frictional engagement with the adjacent rod B, the relatively smaller size of the rod C shown in the diagram and the relative value of its gravity components, together with the frictional drag of the rod D, resulting in a substantial absence of rotation in the rod C which would normally tend to rotate in the same direction as the rods A and B were it not for the frictional drag imposed thereon by the rods B and D. With the balance of forces substantially holding the rod C against rotation, material engaging between said rod and the adjacent drum surface is rubbed and moderately rolled for further separation and cleaning of the material particles, while material engaging between the rods C and B is subjected to a similar rubbing and moderate rolling action. The weight of the rod D is resolved into a major component urging said rod against the adjacent rod C and into a minor component holding said rod against the drum interior, the frictional engagement between the rods D and C being hence greater than that between the rod D and the drum interior so that said rod D would tend to be held against rotation were it not for the reaction of the terminal rod E thereagainst, but the rod E has a major gravity component urging it against the rod D and a minor component reacting against the drum interior, which minor component is productive of a relative slow rotation of the rod E in the same direction as the travel of the drum interior, which rotation is transmitted to the rod D in the form of a relatively still slower rotation of said latter rod in a direction opposed to that of the rod E and drum, the result being that material engaged between contacting portions of the rods C, D, and E, as well as between said rods and the adjacent drum surface, is subjected to a combined rubbing and rolling action produced by the relative slip between such contacting surfaces and is hence rubbed and rolled in a progressively more moderate manner for thorough separation of the particles, one from another, and efficient cleaning of the particles surfaces. Naturally, the larger and heavier pieces of the material to be disintegrated tend to remain at or return to the lower portion of the drum where they are subjected to the relatively greater pressures imposed by the rods **22** and to the relatively more rapid rolling and rubbing effects imparted by said rods, while the finer material is carried upwardly away from the heavier material for thorough cleaning of the particle surfaces and complete detachment of the material particles by the action of those rods having a relatively greater rubbing and more moderate pressure action.

Figures 6 to 9, inclusive, illustrate the relative direction of rotation resulting from various arrangements of two larger and four smaller rods **22** relative to a drum orbit **26** corresponding with that shown in Figure 5. Whatever be the specific arrangement of rods employed, inspection of these diagrams will indicate that in every instance certain of the rods rotate in one direction corresponding with the rotative direction of the drum orbit, while others of the rods rotate in the opposite direction, which condition is inevitably productive of a certain amount of slippage between adjacent rods and between certain of the rods and the drum surface for development of a rubbing or scrubbing effect on material fed to the drum interior. With a moderate speed of drum rotation and the limited number of rods **22** employed, there is no cascading effect of the rods and hence any impact effect which might be destructive of the material particles is eliminated.

The typical apparatus through which the improved method may be advantageously practiced has been described at some length in order to emphasize the characteristic action essential to the results contemplated by the method. In the treatment of differing materials, variations in the form, size, operative speeds, and specific arrangements of the elements constituting the apparatus may be necessary for best results, some arrangement of means productive of a combined rolling and rubbing action on the material with no destructive impact effect and operating at pressures sufficient to detach the material particles from one another without rupture of said particles, being essential to practice of the method. For efficient treatment of certain materials it may be desirable to employ balls instead of rods, to utilize rolling elements having relatively yieldable surfaces, either alone or in combination with other elements having either yieldable or hard surfaces, and to vary the relative size, weight, and number of the rolling elements in operative association with various drum diameters and rates of rotation.

The apparatus described may be advantageously utilized on materials other than ores and minerals, and may, for example, be arranged to disintegrate and clean fibrous material, to detach fiber from its rubber coating in the separation of previously combined associations of fiber and rubber, and to specifically treat various materials whereof the complete detachment and surface cleaning of the constituent particles is sought.

The improved method consists in first treating and sizing the material in a manner and to a degree which will adapt the material to the further stages of the process. This may conveniently be done by breaking down the material through suitable crushing or comminuting apparatus and screening of the broken material to a size which may be conveniently treated in the disintegrating apparatus without displacing the elements of such apparatus from their relative positions. This size will vary with the particular size and arrangement of elements in the apparatus to be employed and with the specific nature of the material under treatment, but the material when fed to the disintegrating apparatus should contain no pieces having a maximum dimension greater than the radius of the smallest rolling element comprised in the apparatus. The sized material may be washed, if desired, for the elimination of slimes, excess fines, and colloidal matter, but this step may be omitted where the material sought to be recovered is carried in the slimes and fines. After initial conditioning as above set forth, the material is fed to the interior of the drum **10** through the chute **19**, and is therein subjected to the rolling and scrubbing action of the rods **22**, or equivalent members. The material is preferably treated wet and is suitably associated, in any desired manner, with a supply of water sufficient to form a pulp within the drum **10** having a consistency which will permit relatively slow flow from the intake to the discharge end of the drum, thereby insuring that all of the material will be repetitiously subjected to the action of the rods **22**. The feed of material to the drum **10** should be so proportioned as to maintain a relatively thin layer of material within said drum and the consistency of the pulp should be such as will minimize splashing within the drum at the speed of drum rotation employed. Since the rolling elements of the apparatus remain at all times against the inner surface of the drum without cascading, both ends of the drum may be open to facilitate inspection of operations as well as to enhance convenience of maintenance and rehabilitation of the apparatus. The varying directions of rotation of the rods **22** act to thoroughly stir, mix, and agitate the pulp material during its travel from the intake to the discharge end of the drum, so that every particle of such material is repatedly subjected to the rolling and rubbing action of the rods, the thoroughly disintegrated material finding its way to the zones of relatively lesser pressures and more moderate rubbing action where they are lightly but thoroughly cleaned, while the heavier pieces of the material are returned to the zones of greater pressures and more violent action until their complete disintegration is accomplished. The relative rotation of the rolling elements comprised in the apparatus is not necessarily constant, since the frictional resistances between adjacent such elements as well as between the elements and adjacent drum portions will vary with the amount and character of the material engaged therebetween, the result being that such rolling elements will be subject to variation in their directions and speeds of relative rotation with a consequent more thorough agitation and stirring of the pulp material and enhanced cleaning and separatory effect thereon.

By the time the pulp material has traversed the length of the drum **10**, it is thoroughly disintegrated to the form of its constituent granular particles, each of which has had its surfaces repeatedly rubbed and scrubbed free of adhering binder or similar agent, the material then escaping through the outlets **20** or **21** for such treatment through separatory means or action by separatory processes as may be effective for the separation and separate recovery desired. Material treated by the improved method is particularly well conditioned for separation by froth flotation processes, since the surfaces of the individual material particles are free from contaminating adherent matter which might hamper the effect of the reagents employed for the separation desired.

Since the apparatus whereby the improved method may be practiced is susceptible of infinite variation without material change in the functional characteristics productive of the treatment sought, and since changes and variations in degree and in relative operative association of the phases constituting the improved method may be had, and may in fact be inherent in the practice of the improved method, I wish to be understood as being limited solely by the scope of the appended claims, rather than by any details of the illustrative showing and foregoing description.

I claim as my invention—

1. The method of treating naturally granular material for the non-destructive separation and cleaning of its constituent granular particles, which consists of rubbing and rolling the material under and between a single layer of smooth, cylindrical blunging elements of less weights than will crush the material particles and loosely disposed in parallel, contacting adjacently for gravity-actuated, free-rolling, non-cascading cooperation with the smooth inner surface of a slowly-rotating, substantially-horizontal, cylindrical mill, whereby said material is subjected to differential pressures and frictions free from impact effect.

2. The method of treating naturally granular material for the non-destructive separation and cleaning of its constituent granular particles, which consists of rubbing and rolling the material under and between a single layer of smooth, cylindrical blunging elements of varying diameters and of less weights than will crush the material particles and loosely disposed in parallel, contacting adjacency for gravity-actuated, free-rolling, non-cascading cooperation with the smooth inner surface of a slowly-rotating, substantially-horizontal, cylindrical mill, whereby said material is subjected to differential pressures and frictions free from impact effect.

THEODORE EARLE.