C. Q. PAYNE.

METHOD OF AND APPARATUS FOR THE GRADING OR SIZING OF MATERIALS OF ALL KINDS.

APPLICATION FILED DEC. 6, 1915. RENEWED NOV. 3, 1917.

1,283,284.

Patented Oct. 29, 1918.

2 SHEETS—SHEET 1.

Fig. 1.

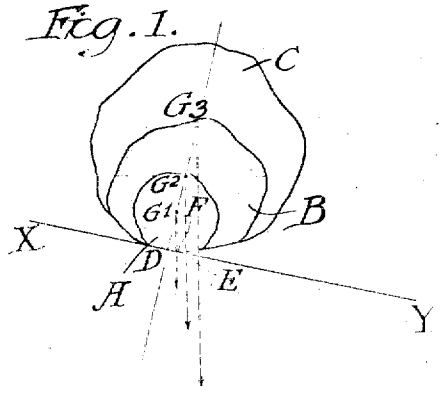


Fig. 2.

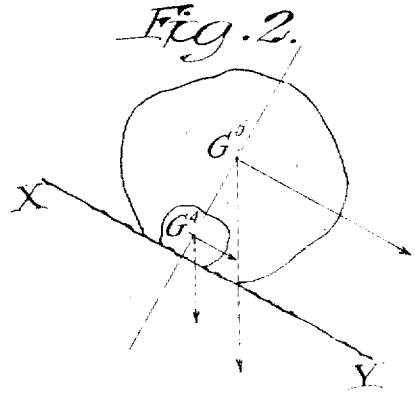


Fig. 3.

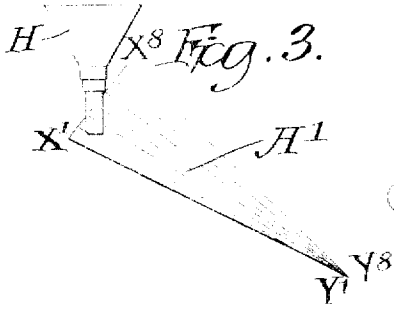


Fig. 4.

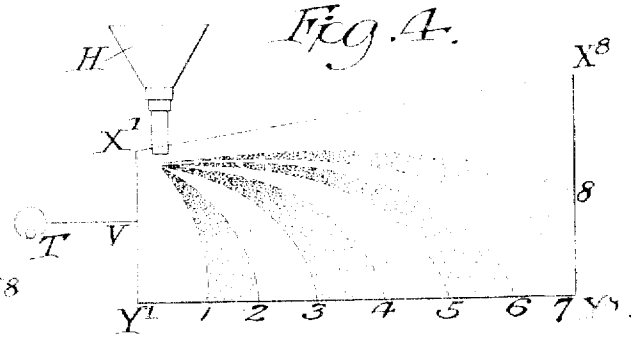
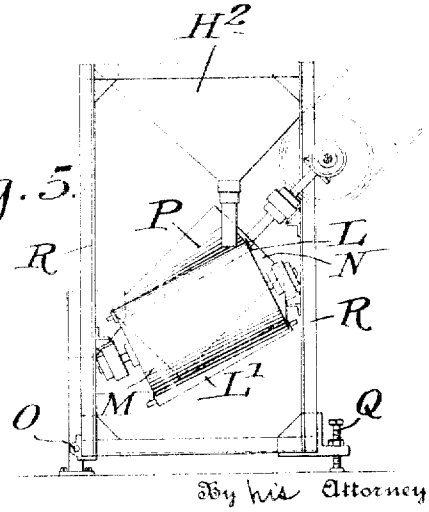


Fig. 5.



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2 SHEETS—SHEET 2.

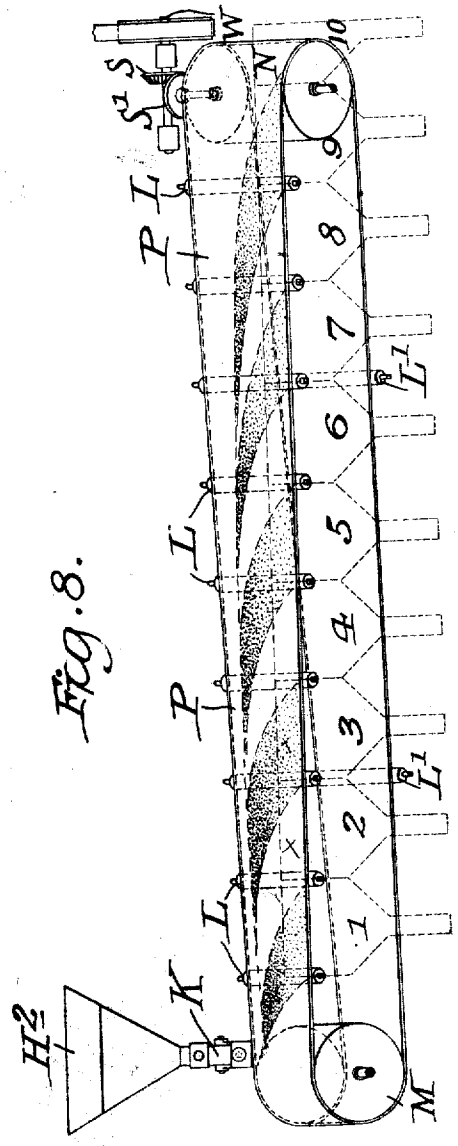


Fig. 8.

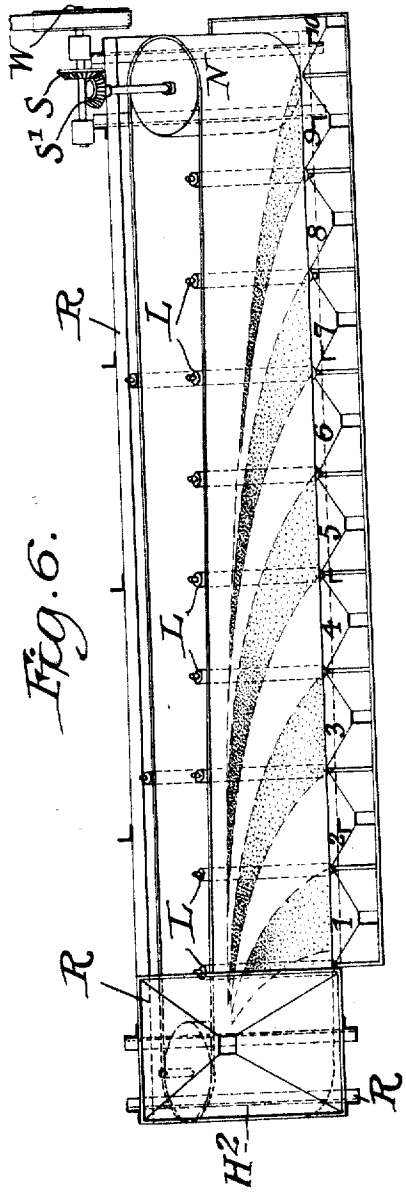


Fig. 6.

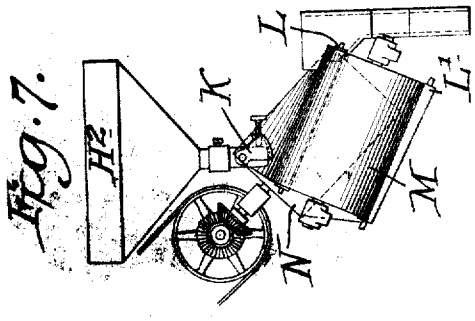


Fig. 7.

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METHOD OF AND APPARATUS FOR THE GRADING OR SIZING OF MATERIALS OF ALL KINDS.

1,283,284. Specification of Letters Patent. Patented Oct. 29, 1918.

Application filed December 6, 1916, Serial No. 135,334. Renewed November 3, 1917. Serial No. 200,173.

To all whom it may concern:

Be it known that I, CLARENCE Q. PAYNE, a citizen of the United States, residing in the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for the Grading or Sizing of Materials of All Kinds, of which the following is a full and true description.

My invention relates to a method of and apparatus for sizing, without the use of screens, of unsized or crushed materials of all kinds, whereby the particles of different sizes are so acted upon that they are enabled to arrange themselves in a series of groups, in each of which the individual particles are of approximately equal volumes or sizes.

My invention consists in acting upon material while it is being conveyed lengthwise of a transversely inclined warped or helicoidal surface, so that differences in the statical moments, and in the frictional resistances of the different sized particles composing the material cause them to move across the transporting surface at different points thereof, and thus to separate themselves into a series of groups of different sized particles.

It also consists in means for varying the inclination of the warped or helicoidal surface as a whole, so as to adapt it more perfectly to the grading or sizing of different materials in which the relative proportions of the coarse or fine sizes thereof vary widely.

In the accompanying drawings, Figures 1 and 2 illustrate the principles involved when particles of different sizes roll and slide upon an inclined surface. Figs. 3 and 4 illustrate the application of my invention to a reciprocating table. Fig. 5 shows in end view an inclined endless belt with its supporting frame and means for tilting the frame sidewise so that the transverse inclination of the belt may be varied as a whole. Figs. 6, 7 and 8 illustrate in plan, end and side views the application of my invention to an inclined endless belt, upon which the sizing takes place.

To illustrate more clearly the underlying principles embodied in my invention, I have shown in Figs. 1 and 2 on a greatly enlarged scale particles of different sizes which rest upon inclined planes X—Y. In Fig. 1 three particles, A, B and C, of irregular sizes are assumed to rest upon an equal area represented in section by the line D—E. The stability of a particle resting upon such an inclined plane is the resistance which its weight enables it to oppose against forces tending to overturn it, or to slide it along its support. The statical moment is the measure of the stability of a particle, and is the product of its weight by the distance of its line of gravity from its edge of rotation. When resting on an inclined plane, the line of gravity falls toward the lower edge of the body, and the condition of not being overturned by its own weight is that the line of gravity must fall within this edge.

In the particular illustration of particles of different sizes, such as A, B and C, Fig. 1, whose centers of gravity are represented by G^1, G^2 and G^3, it is clear that while the particle A is in a condition of stable equilibrium, since its overturning is opposed by the statical moment equivalent to the weight G^1 multiplied by the distance F—E, the largest particle C could not remain in the position shown in Fig. 1, since its vertical line of gravity falls beyond the edge of rotation E. It will therefore roll down the incline X—Y by its own weight. The particle B, on the other hand, is in a position of unstable equilibrium, since the vertical line through the center of gravity G^2 passes through the edge of rotation E. Its statical moment being zero, only a slight force will be required to overturn it and cause it to roll down the incline X—Y.

The above is intended to illustrate diagrammatically what is also a matter of common observation; viz., that a large particle resting upon an inclined surface is in a position of less stable equilibrium than a small particle. Its center of gravity being at a greater distance above its point of support, it is more easily acted upon by jarring or by an overturning force. It follows from the above considerations that when the angle of inclination of a smooth surface upon which rest particles of different sizes is gradually increased, the particles of the largest size are the first to roll down the incline. As the angle of the surface is still further increased, the next largest particles start rolling, followed successively by particles of smaller and smaller diameter, until finally from an inclination of about 45 degrees even the finest particles are discharged.

Particles also move down an inclined surface by sliding as well as by overturning. The condition of stability against sliding is

that the component of the force tending to cause it to slide shall be less than the product of the weight of the particle into the coefficient of friction between the base of the particle and its supporting surface. This coefficient of friction is the tangent of the angle of repose, or the angle at which the supporting surface must be raised before the particle begins to slide. If all friction could be eliminated between the base of the particles and their supporting surface, they would then all start at the same time and would move with the same velocity down the inclined surface irrespective of their size. Such a condition might, by way of illustration, be conceived of by assuming that the cushion of steam under globules of water in a spheroidal state on a hot plate does away with sliding friction. Globules of all sizes would then move with equal facility with the slightest inclination of the plate. In the case of crushed ore particles resting upon a smooth surface, however, it is noticeable that small particles have a higher coefficient of friction than the large particles; i. e., their angle of repose is steeper.

If a smooth surface of almost any material be examined with a magnifying glass, it is seen to have innumerable irregularities such as minute pits and hollows, and the smaller the particles which rest upon such a surface, the more they are able to obtain footholds for their projecting points and edges, and thus to resist motion. Such a relation is indicated approximately on an enlarged scale in Fig. 2.

It is the object of my invention to utilize differences in stability, both of rolling and of sliding in the treatment of unsized particles upon an inclined surface, in order to size them, as simply and economically as possible. In accomplishing this purpose, I make use of a surface whose transverse inclination progressively increases as the material is conveyed lengthwise thereof, so that particles of a decreasing size are successively acted on and discharged at separate intervals.

The object of my invention can also be best attained by avoiding mass action of the material undergoing sizing, although I am aware that this principle has heretofore been employed for similar work by other types of apparatus. My invention, on the contrary, contemplates the treatment of the material in a thin sheet at a high speed upon a smooth surface, whose transverse inclination is progressively increased as the material is conveyed in the direction of its length. My invention does not contemplate the use of surfaces having artificial roughnesses or irregularities such as corrugations or grooves, which have heretofore been proposed to accomplish similar work.

The process of sizing covered by my invention may be embodied in various types of apparatus, two of which are respectively illustrated in Figs. 3, 4, and in Figs. 5, 6, 7 and 8. Other types or modifications thereof will suggest themselves to those skilled in the art.

In Figs. 3 and 4 a reciprocating table is shown whose surface A^1 is given a transverse inclination, and is so curved that the angle of inclination gradually increases from X^1, Y^1 to X^5 Y^5. Such a curved surface is technically defined as a warped or helicoidal surface. This is a special form of warped surface, which is formed by a right line generatrix moving in contact with two directrices, one a right line and the other a line of double curvature such as the arc of a helix. In operation the table is given a reciprocating motion by means of any convenient head motion, indicated diagrammatically by TV, so as to impart a slow forward and quick return motion to the table, in order to propel the material fed upon it in the direction of its length.

Upon feeding the unsized material upon the table A^1 from the hopper H, the motion of the table causes the particles quickly to fan out as they move lengthwise of the table deck. In doing so the largest sized particles of the feed material are the first to start rolling and sliding across the table, since their statical moment is least upon a moving inclined surface. The largest particles therefore reach the points 1, 2 at the edge of the table and are discharged. As the material is moved farther and farther along the curved surface of the table deck, it encounters an increasing angular inclination in a transverse direction. This causes the next largest particles to be discharged at the points 2, 3 of the table edge, and so on until the finest of all the particles are removed at 7, 8, thus effecting a sizing of the material into as many groups of different sizes as may be desired.

In Figs. 6, 7 and 8 I have shown the principle of my invention applied to an endless belt conveyer. Here the end pulleys M and N support a conveyer belt I in an inclined position by means of the frame R. This frame and accessory mechanical supports are omitted in Figs. 7 and 8 in order to show the belt more clearly. The belt may be of any convenient flexible material such as leather, rubber, cotton, etc. It is supported by a series of idlers L, L, between the two end pulleys M and N. The front edge of the belt is preferably maintained in a horizontal position as shown in Fig 7 for convenience in collecting the sized material discharged from it.

The belt is driven in any convenient manner as, for example, by means of bevel gears S, S and a countershaft W, operated by pul-

ley and belt from an outside source of power. The pulley N at the driving end of the belt is maintained at a steeper angle than the pulley M at the feed end. This disposition of the pulley and the intervening idlers L, L, causes the upper surface of the belt to occupy a twisted or curved position, as indicated more clearly in Fig. 7 in end view. Such a surface becomes in effect a warped or helicoidal surface, and particles conveyed lengthwise thereof are supported upon a progressively steeper angle of the belt surface, as shown in end view of the belt, Fig. 7.

If, for example, the pulley, M, is supported at an angle of 25°, with the horizon, and pulley N at an angle of 45°, then the intermediate idlers L, L may be so placed as to divide the difference between these two angles, viz., 20°, uniformly among themselves, so that the transverse inclination of the belt surface will vary by uniform increments.

The rate of the transverse angular change of such a surface is defined by the frame and supporting rollers, and is not conditioned by the rate of change in the preceding or following sections of the surface. The angles of the guide-rollers may therefore be independently varied in order that the zones of separation included between each pair of rollers may be more perfectly adjusted to the separation of the component sizes of the materials to be graded.

In operating this form of belt sizer, the material to be sized is fed from a hopper, H², through the regulating gate K, upon the upper left hand corner of the belt P, which is caused to move in the direction of the arrow by means of the driving mechanism shown at the right hand end of the belt. At the feed end of the belt its transverse inclination is a minimum, and the coarest particles of the material which cannot remain at rest upon such a slope, say 25°, are at once discharged across the belt and are collected in the chute 1. With the advance of the material upon the belt, it reaches and passes a position of greater inclination—say 27° where particles of the next greatest size are discharged by rolling and sliding across the belt into the chute 2. In the same way progressively finer particles as they encounter successively increasing inclinations of the belt surface are discharged from the edge of the belt into the chutes 3, 4, 5, etc., up to 10. By shading alternate bands of particles in Figs. 6 and 7 as they undergo sizing upon the surface of the belt, the action of the belt sizer is indicated diagrammatically somewhat more clearly.

It will be obvious that where a crushed material contains a preponderant amount of the finer sizes, that the steeper slope of the belt sizer will be more in use than the flatter slope. Also where the material contains a larger proportion of coarse sizes, the flatter slope will then be in greater use. In order to adapt the sizer to a wide range of work, I find it desirable to adjust the transverse inclination of the belt as a whole so as to permit the initial and final angles of the belt slope to be more closely controlled. For this purpose, as shown in Fig. 5, the frame RR may be supported by pivoted bearings, O, on one side and by a series of adjusting screws Q, on the other, or any equivalent device, in order to vary the transverse inclination of the belt as a whole in accomplishing the purpose described. By thus varying the transverse angle of inclination of the belt as a whole, and also where it is necessary, by increasing the length of the belt and running it at a high speed, it becomes possible to subdivide any unsized aggregate of particles into as many closely sized groups as may be desired.

Having thus described my invention, I claim:

1. The method of sizing material composed of unsized particles which consists in charging it upon a transversely inclined surface no two consecutive rectilinear elements of which lie in the same plane, and which forms a warped surface, moving said surface longitudinally and causing said particles to occupy progressively increasing angles of inclination upon said surface, discharging progressively diminishing sized particles transversely to the direction of motion of said surface, and separately collecting the different sized particles.

2. The method of sizing material composed of particles of varying sizes which consists in charging it upon a surface having zones of increasing and separately varying transverse declinations, varying the gravitational effects upon said particles by moving them longitudinally thereon, discharging progressively decreasing sizes thereof transversely to the motion of said material, and separately collecting the different sizes.

3. The method of sizing material composed of particles of varying sizes which consists in charging it upon a flexible endless belt whose surface is sub-divided into zones of increasing and separately varying transverse declinations, varying the gravitational effects upon said particles by moving them longitudinally thereon, discharging progressively decreasing sizes thereof transversely to the motion of said material, and separately collecting the different sizes.

4. The method of sizing material composed of unsized particles which consists in charging it upon a helicoidal surface having a series of zones of increasing and separately varying transverse declinations, conveying said material into positions of successively greater declinations thereon, discharging gradually decreasing sizes thereof trans-

versely to the motion of said material, and separately collecting the different sizes.

5. The method of sizing material composed of particles of different sizes, which consists in charging a thin sheet of said material upon a smooth helicodial surface, conveying said material at a high speed into zones of increasing and separately varying transverse declinations thereon, discharging gradually decreasing sizes thereof transversely to the motion of said material, and separately collecting the different sizes.

6. In an apparatus for sizing material composed of unsized particles, the combination of a transversely inclined belt whose upper surface forms a warped surface, means for charging the material to be sized upon one end of said belt, means for moving the belt longitudinally, and means for separately collecting the different sized particles as they are successively released and discharged transversely from said belt.

7. The method of sizing material composed of particles of varying sizes, which consists in charging it upon the upper surface of an endless belt which has a series of zones of increasing and separately varying transverse declinations and forms a helicoidal surface, conveying said material into positions of progressively greater declination thereon, discharging gradually decreasing sizes thereof transversely to the motion of said material and separately collecting the different sizes.

8. In an apparatus for sizing material composed of particles of varying sizes, a flexible support the surface of which is transversely inclined at an increasing and varying angle, in combination with means for moving said surface longitudinally, means for feeding the material to be sized upon said surface, and means for separately collecting the different sized particles as they are released and discharged from said surface.

9. In an apparatus for sizing material composed of particles of varying sizes, a flexible endless belt whose surface is transversely inclined at a gradually increasing and varying angle, in combination with means for moving said belt longitudinally, means for feeding the material to be sized upon said surface, and means for separately collecting the different sized particles as they are released and discharged transversely to the motion of said material.

10. In an apparatus for sizing material composed of unsized particles, an endless belt whose upper surface forms a helicoidal surface, in combination with means for moving said belt longitudinally, means for feeding the material to be sized upon said belt, and means for separately collecting the different sized particles as they are discharged from the belt.

11. In an apparatus for sizing material composed of unsized particles, an endless belt whose upper surface is inclined transversely at a progressively increasing angle, and forms a helicoidal surface between its end supports, in combination with means for moving said belt longitudinally, means for feeding the material to be sized upon one end of said belt, and means for separately collecting the different sized particles as they are progressively released and discharged transversely to the motion of said belt.

12. In an apparatus for sizing material composed of unsized particles, an endless belt whose upper surface is inclined transversely at a progressively increasing angle, and forms a helicoidal surface between its end supports so placed that the outer edge of said belt occupies a horizontal position, in combination with means for moving said belt longitudinally, means for feeding the material to be sized upon one end of said belt, and means for separately collecting the different sized particles as they are progressively released and discharged transversely to the motion of said belt.

13. In an apparatus for sizing material composed of particles of varying sizes, an endless belt whose surface is supported upon a series of guide-rollers which are transversely declined at increasing and separately varying angles, in combination with means for feeding the material to the end of the belt having the zone of least declination, means for conveying said material into the zones of increasing declination, and means for separately collecting the different sizes as they are discharged transversely to the motion of said material.

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Witnesses:
WALTER S. JONES,
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