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ORE CRUSHING APPARATUS.

APPLICATION FILED MAY 9, 1906. RENEWED DEC. 17, 1908.

928,967. **Patented July 27, 1909.**

2 SHEETS—SHEET 1.

Fig. 1

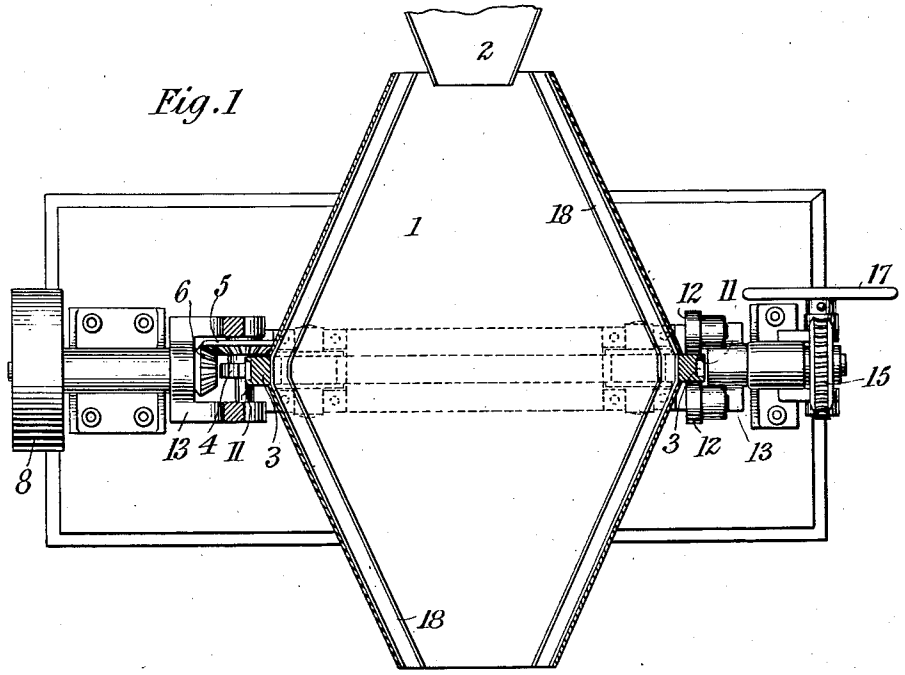

Fig. 2

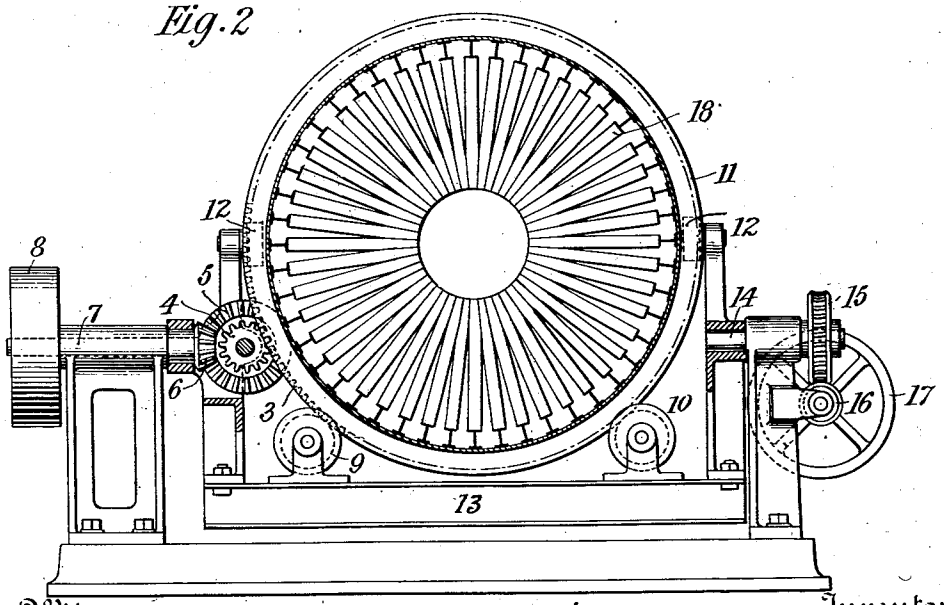

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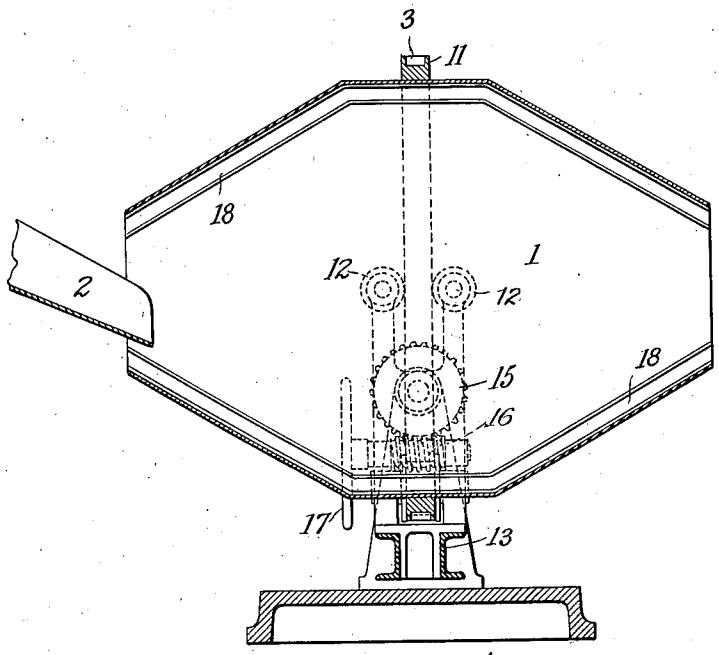
Fig. 3



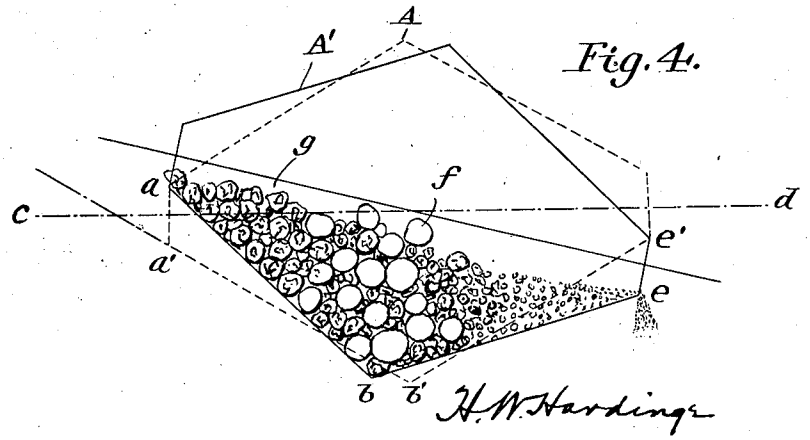


Fig. 4.

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UNITED STATES PATENT OFFICE.

HARRY W. HARDINGE, OF NEW YORK, N. Y., ASSIGNOR TO HARDINGE CONICAL MILL COMPANY, A CORPORATION OF NEW YORK.

ORE-CRUSHING APPARATUS.

No. 928,967. Specification of Letters Patent. Patented July 27, 1909.

Application filed May 9, 1906, Serial No. 315,858. Renewed December 17, 1908. Serial No. 468,056.

To all whom it may concern:

Be it known that I, HARRY W. HARDINGE, a citizen of the United States, residing in New York, in the county and State of New York, have invented certain new and useful Improvements in Ore-Crushing Apparatus, of which the following is a specification, reference being had to the drawings accompanying and forming part of the same.

My invention relates to apparatus for crushing, dividing, or disintegrating ores and other substances, and has for its chief object to provide an apparatus which shall perform its work rapidly and efficiently and which shall also be capable of reducing the material to particles of any desired size, from fine powder to coarse granules or bits, at will. Such an apparatus is adaptable to treat ores of various kinds and reduce them to the condition of division best suited for the extraction of metals which they contain.

The invention relates more particularly to that type of machines in which ore or other material is subjected to a tumbling action in a drum or other rotating receptacle, as distinguished from machines in which the material is broken up by the crushing action of stamps, jaws, or similar crushing elements.

The essential feature of the invention is the tumbling barrel or drum, which is in the form of two cones placed base to base, with or without an intermediate cylindrical part. The ends of the barrel are open, one to receive the material to be treated and the other to discharge the same in the desired state of division. The barrel is rotated about its axis, which may be more or less inclined, and the tumbling of the large masses of material causes them to break up, by impact and attrition on each other or with the help of pebbles, metal balls, or other non-friable crushing bodies. As the barrel rotates, the larger masses of material and the non-friable crushing bodies gravitate to its center or greatest diameter, the size of the masses and bodies being smaller and smaller toward the ends of the barrel. Consequently the larger masses have greater fall in the tumbling action and are subjected to correspondingly heavier impacts, resulting in rapid disintegration. As the masses or lumps of material are broken into pieces the latter are displaced by the bodies and masses larger than themselves and are thus carried toward the ends of the barrel, where they are further acted upon by correspondingly smaller bodies until they are reduced to a size determined by the rate of flow of the material through the barrel. In their passage to the outlet the small bits or pieces are subjected more or less to the disintegrating action of their impact and attrition on each other as well as on the larger bodies, hence the longer it takes the bits or pieces to reach the outlet the longer they will be subjected to this disintegrating action and the smaller they will be when the outlet is reached. The rate or speed of their travel to the outlet depends upon the inclination of the tumbling barrel, so that if the barrel is but slightly inclined their speed will be slow and they will be more finely divided, whereas if the inclination of the barrel be greater their speed will be correspondingly increased and they will issue in larger pieces. The barrel may be revolved at the speed most effective for the rapid reduction of the material, the size of the ultimate particles being determined by the inclination of the barrel and consequently the length of time they remain therein subject to the disintegration action.

A convenient embodiment of the invention is illustrated in the annexed drawings, in which—

Figure 1 is a plan view, with the barrel in horizontal longitudinal section. Fig. 2 is an end view, with the barrel in vertical transverse section. Fig. 3 is a vertical longitudinal section, showing also a modified form of barrel. Fig. 4 is a diagram illustrating the action of the apparatus.

The tumbling barrel or drum is indicated by 1. As shown in Fig. 1 it is in the form of two hollow cones, of the same pitch or slant relative to their axes placed base to base, so that the interior forms a single, unitary chamber or compartment. The barrel is made preferably of heavy sheet steel. The ends of the barrel are open at the longitudinal axes thereof, and at one end is any suitable hopper or chute, as 2, to direct the material into the interior.

As already stated, the barrel is revolved about its axis and is capable of being tilted or inclined from the horizontal, at will. Any suitable mechanism for effecting these movements may be employed, as for example the devices illustrated. For the purpose of rotating the barrel it is provided, preferably at

its center or at the point of greatest periphery, with a toothed rack or gear 3, engaged by a driving pinion 4 on a short shaft which carries a bevel gear 5 meshing with a gear 6 on a driving shaft 7. The latter carries a driving pulley 8, for connection with any convenient source of power. The barrel itself rotates on grooved rollers 9, 10, engaging the flanges 11 of the rack 3, and is held against endwise movement by rollers 12, located at opposite sides of the barrel and bearing on the side faces of the rack 3. The barrel and parts connected with it, except the driving shaft and its pulley and bevel gear, are mounted on a swinging frame 13, suspended at one side on the driving shaft 7 and at the other side by a trunnion 14. On the outer end of the latter is a worm gear 15, in mesh with a worm 16, which is rotated manually by a hand wheel 17. It is clear that by turning the hand wheel the frame 13, and with it the drum, may be tilted on the shaft 7 and trunnion 14 and the drum or barrel maintained with its axis of rotation at any desired inclination.

The operation of the apparatus is as follows: The material to be disintegrated or divided is discharged into the higher end of the barrel. The material may be dry, or a stream of water may be kept flowing through the barrel, from the same chute. The material is tumbled by the rotation of the barrel, and by the impact of the masses on each other and by their mutual attrition or by grinding between the balls or pebbles they are disintegrated more or less rapidly, depending on the friability of the material composing them. The larger bodies gravitate constantly to the lowermost point of the barrel, while the smaller pieces, and the particles or bits which are broken off, flow or travel over the lumps in the center toward the outlet end of the barrel, approximately in proportion to their size. That is to say, the size of the lumps of masses in the barrel decreases from the center toward the outlet. Finally the level of the material in the barrel reaches the outlet, and the small pieces or bits pass out. The size of the particles when they reach the outlet depends upon the degree of inclination of the barrel. Thus, if the inclination be slight the travel of the material through the barrel will be slow, and the masses will be subjected for a longer time to the disintegrating action and consequently the material will be more finely divided. If the inclination be considerable the travel of the material will be fast and less disintegration will occur. By varying the inclination of the barrel the size of the particles discharged therefrom can be determined with a reasonable degree of accuracy and the ore or other material can thus be reduced to pieces of any desired size.

The displacement of the smaller masses by the larger, resulting from the tilting of the barrel, is believed to be due to the fact that the tilting of the barrel makes one cone (the inlet cone) in effect steeper, relative to the horizontal, than the other cone. This will be more readily understood in connection with Fig. 4. In the latter figure, A represents in dotted lines a barrel with its axis horizontal, and A′, in full lines, represents the same barrel with its axis tilted or inclined to the horizontal, with the inlet opening higher than the outlet opening. It will be observed that the line *a*—*b* makes a greater angle with the horizontal, represented by the dotted line *c*—*d*, than does the line *a′*—*b′*, while the line *b*—*e* makes a smaller angle with the horizontal than does the line *b′*—*e′*. The result is that masses or lumps in the inlet cone rest on a steeper incline than do those in the outlet cone, and the former masses therefore have greater tendency to seek the lowest point of the barrel than do the masses in the outlet cone, the incline of which is less steep. Furthermore, the larger masses, having greater momentum, tend constantly to displace from the lowest point of the barrel the smaller masses, which have less weight and correspondingly less momentum. In consequence, the larger masses collect in the central transverse zone of the barrel, displacing the smaller and lighter masses and particles up the lesser incline of the second cone. In the figure under consideration is illustrated the way the masses arrange themselves. It will be seen that the loose, freely movable crushing bodies *f* are at the center of the barrel. As the barrel rotates these balls or pebbles are carried up the side of the barrel and finally fall with considerable force upon the material *q* which is delivered through the inlet opening. The material is thus broken up into smaller pieces, which the balls drive before them. In passing through the zone of balls or pebbles these smaller pieces are subjected to the frequent impacts of the balls or pebbles and are gradually reduced in size by division. Beyond the zone of balls the pieces or masses of material are further broken up by mutual impact and attrition, until they pass out of the barrel, as shown in Fig. 4.

Material which is comparatively soft or friable may be sufficiently disintegrated by the interaction of its own lumps or masses, without the assistance of pebbles, metal balls or other non-friable bodies, but such crushing bodies may be used if desired, and may be necessary where relatively hard material is to be disintegrated. In the appended claims "crushing bodies" are included as an element of the combination, but it is to be understood that these bodies may, as just stated, be the lumps or masses of the ore or other material undergoing treatment, or may be the metal balls, or flint pebbles, etc.,

referred to above. In the former case the "crushing bodies" are of course themselves disintegrated, but they are constantly replaced by the new lumps delivered through the inlet opening.

Inasmuch as the wear on the interior of the drum is considerable it is desirable to provide a protecting lining therefor. For this purpose I have devised means whereby in the operation of the machine there is formed on the inside of the drum or barrel a layer or lining composed of the material undergoing treatment, or of crushing bodies, or both. To secure this result the interior surface of the barrel is provided with longitudinal flanges or ribs, formed by angle irons, T-irons, or other suitable shapes, as for example the I-beams at 18, Fig. 2. The spaces between these ribs become tightly packed with lumps or pieces of different sizes, leaving only the inner edges or faces of the ribs exposed. This effectively protects the drum, while the grooved or fluted contour thus produced increases the disintegrating action since it causes the lumps to be carried farther up the sides of the drum before being thrown toward the center. At the same time the inner surface of the barrel is left substantially smooth, in the sense that it is devoid of flanges or projections such as are used in mixing machines for commingling two or more materials. The lining thus formed by the wedging and packing of the material between the ribs renews itself by the prompt packing-in of new lumps or pebbles whenever old lumps, loosened by wear, are dislodged.

In the form shown in Fig. 3 the central part of the drum is cylindrical, to provide for a greater quantity of large masses of lumps.

From the foregoing it will be seen that my invention provides an apparatus by which ores and other friable materials can be rapidly disintegrated and reduced to particles of any desired size. The power required to drive the machine is small in comparison with the results obtained, thus making the machine economical in operation.

The mechanism shown and described for rotating the barrel and tilting it to any desired angle is not an essential part of the invention, since any suitable devices for the purposes may be employed.

What I claim is:

1. In an apparatus for disintegrating ores and other materials, a tumbling barrel or drum composed of a pair of cones of the same pitch arranged base to base and forming a single chamber or compartment, said barrel or drum having axial inlet and outlet openings at its ends, means for supporting the barrel or drum with its longitudinal axis inclined to the horizontal, and means for rotating the barrel or drum about said axis, in combination with a multiplicity of crushing bodies freely movable in every direction inside the barrel or drum.

2. In an apparatus for disintegrating ores and other materials, a tumbling barrel or drum composed of a pair of cones of the same pitch arranged base to base and forming a single chamber or compartment, said barrel or drum having axial inlet and outlet openings at its ends, means for rotating the barrel or drum about its longitudinal axis, and means for adjusting the inclination of the said axis relative to the horizontal, in combination with a multiplicity of crushing bodies freely movable in every direction inside the barrel or drum.

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