April 18, 1939. W. H. SCHACHT 2,155,151

METHOD OF CRUSHING

Filed March 26, 1934 3 Sheets-Sheet 1

Fig. 1

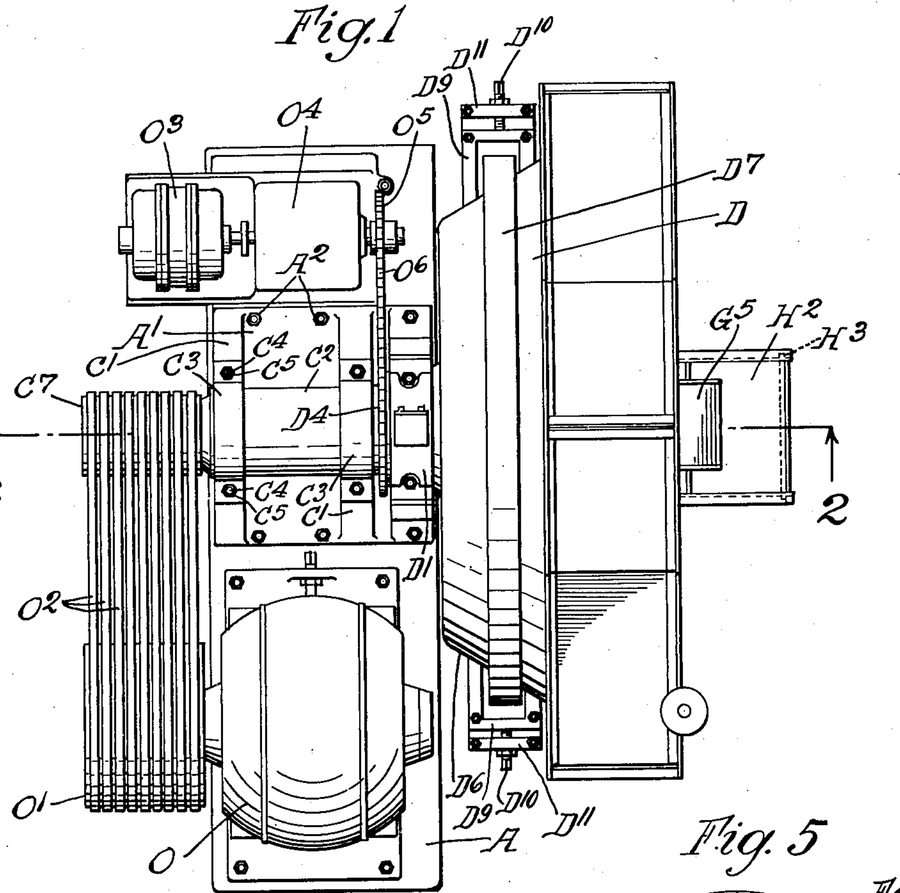

Fig. 5

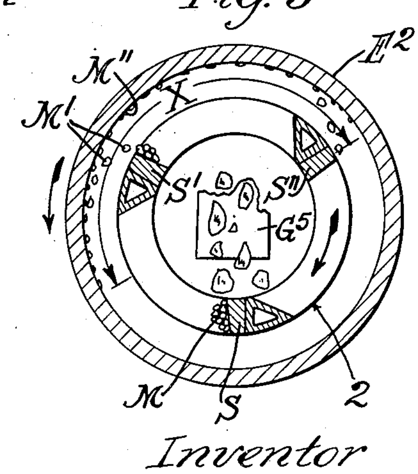

Fig. 6

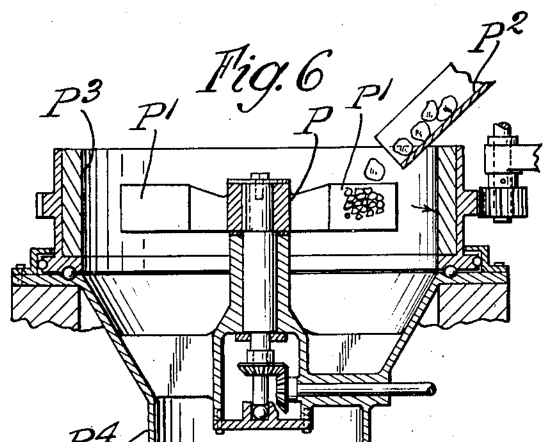

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Fig. 3

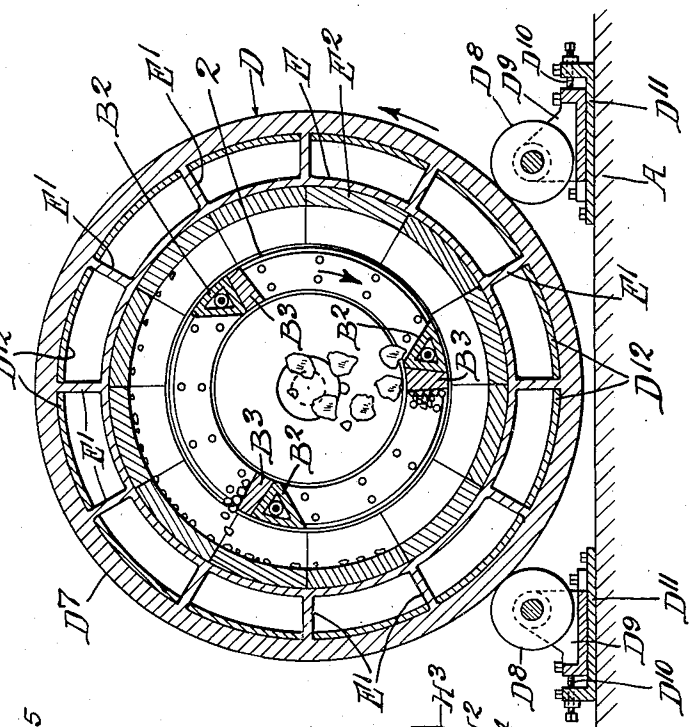
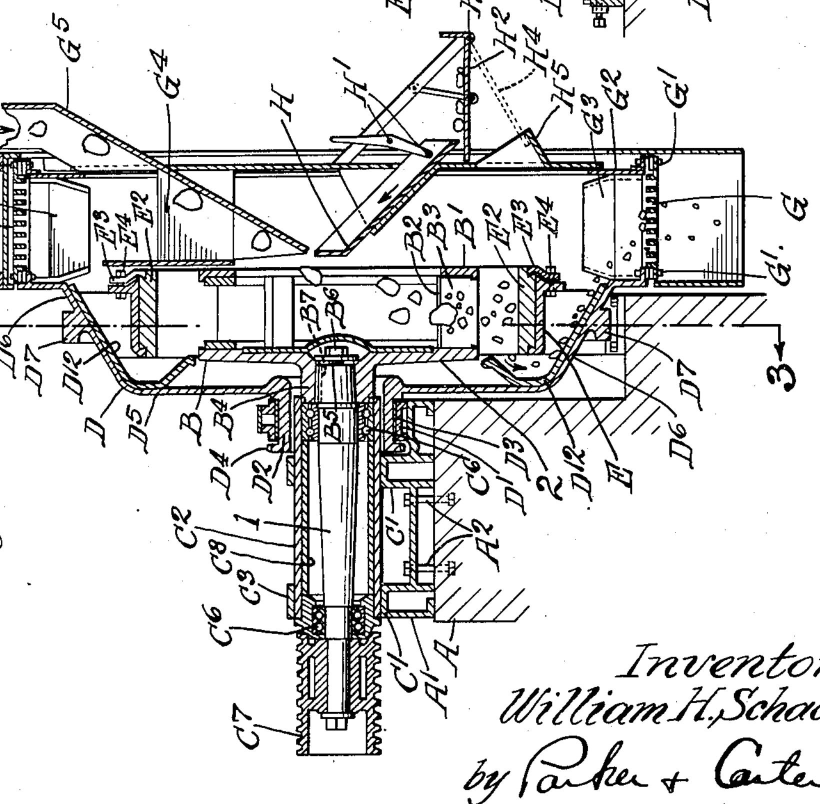


Fig. 2



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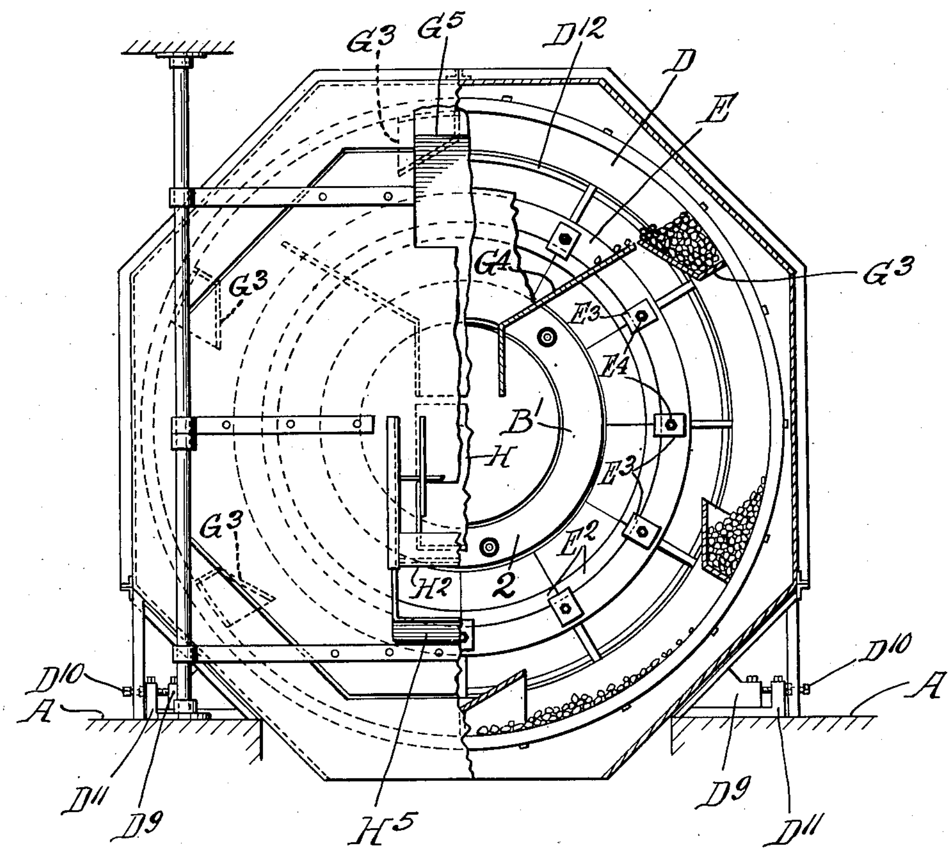
Filed March 26, 1934 3 Sheets-Sheet 3

Fig. 4



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UNITED STATES PATENT OFFICE

2,155,151

METHOD OF CRUSHING

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Application March 26, 1934, Serial No. 717,288

4 Claims. (Cl. 83—46)

My invention relates to an improvement in crushing or pulverizing methods. It has for one object the provision of a crushing method wherein freely falling particles, moving for example under the influence of gravity, are crushed or disintegrated by a crushing impact, which impact is received while the particles are unsupported and is delivered at a time when the particles are not engaged by any crushing surface other than the impact surface. I avoid any nip or crushing action in which the particle is simultaneously gripped by two opposed surfaces. Another purpose is the provision of a crushing method in which the particles impacted, or the smaller particles to which they are reduced by the impact, are directed by such impact against a secondary impacting surface, where an ensuing crushing or disintegrating impact is received. Another purpose is the provision of a crushing method in which the particles to be crushed are passed by gravity through a crushing zone defined by the path of movement of a succession of impacting members. Other objects will appear from time to time throughout the specification and claims.

The present application is a continuation-in-part of my application No. 650,597 filed on January 7, 1933.

I illustrate my invention more or less diagrammatically in the accompanying drawings wherein—

Figure 1 illustrates a plan view;

Figure 2 is a section on the line 2—2 of Figure 1;

Figure 3 is a section on the line 3—3 of Figure 2;

Figure 4 is a front end view with parts in section;

Figure 5 is a schematic diagram; and

Figure 6 is a vertical section of a variant form.

Like parts are indicated by like symbols throughout the specification and drawings.

Referring to the drawings, A generally indicates any suitable fixed supporting structure upon which may be mounted any suitable supporting member A^1 held in place for example by the bolts A^2.

1 indicates an impeller spindle to which is secured the impeller structure generally indicated as 2 which includes a disc B and a laterally spaced ring B^1, the ring and disc being connected by a plurality of impeller vanes or struts B^2 which are clearly shown in section as in Figure 3. Positioned adjacent and preferably abutting against the impeller vanes B^2 are the impeller striking or wearing plates B^3 of which three are shown in Figures 3 and 5, it being understood that the number may be varied. The impeller plate B may include a collar or hub B^4 surrounding the end of the impeller shaft 1 the parts being held against movement as by the bolt B^5 and the nut B^6 and the key B^7. Any suitable means may be employed for rotatably supporting the impeller shaft or spindle 1 as for example the pedestal and hub bearing bed plate A^1 with its pedestal supports C^1 in which may be mounted the shaft or spindle bearing sleeve C^2 held in place as by the clamp members C^3 which may be tightened as by the bolts C^4 and nuts C^5. Positioned within the bearing sleeve C^2 are any suitable roller bearings C^6 within the inner race of which is positioned the shaft or spindle 1. C^7 indicates a terminal driving pulley for the shaft or spindle which may be secured to the end of the spindle 1 whereby the spindle and the impeller may be rotated. C^8 indicates a main bearing adjusting sleeve within the spindle bearing sleeve C^2. It will be clear from the figures that whereas the member B is shown as a disc the member B^1 is a ring laterally spaced from and opposite to the periphery of the disc B, whereby, as will later appear, material may be fed for free gravital fall between the disc B and ring B^1 to the wearing plate B^3.

Surrounding the impeller structure is the impeller housing structure generally indicated as D. D^1 is the impeller housing bearing which may be mounted in any suitable way on the base A. D^2 indicates an impeller housing ring bearing hub. D^3 indicates any suitable anti-friction bearing and D^4 is the impeller housing driving sprocket. The housing includes a flat portion D^5 which is outwardly flared as at D^6 and terminates in a species of circular track D^7 which may be supported upon trunnion rollers D^8 rotatable upon adjustable trunnion roller frames D^9 which may be adjusted as by the screw device D^{10} upon the trunnion roller base D^{11}. The interior of the impeller housing is provided with any suitable liner plates D^{12} as shown in Figure 2.

Mounted within and rotating with the impeller housing is a reflector ring E. The reflector ring may be supported for example by a plurality of generally radial elements or braces E^1 as will be clear from Figure 3. E^2 indicate any suitable reflecting ring striker plates which may be held in position as by striker plate clamps E^3 and clamp bolts E^4. As will be clear for example from Figure 2 the striker plates lie in the plane of rotation of the impeller wearing plates B^3 and any material which passes between the impeller plates or which is driven from the impeller plates by the crushing or disintegrating impact, is received by the striking plates. As will later appear, the rate of feed and the rate of rotation is such that material cannot drop through the path of movement of the striking plates without receiving a crushing or disintegrating impact, the action of which is indicated for example in Figures 3 and 5.

Further secured to the impeller housing structure is a circumferential grizzly or screen generally indicated as G. It may be bolted or otherwise suitably secured to the outer edge of the impeller housing as at G^1 and is provided with a forward circumferential side ring G^2.

Associated with the rotating grizzly structure are a plurality of elevator buckets G^3 which therefore rotate unitarily with the impeller housing. Any material which fails to pass through the grizzly or screen is picked up by the buckets and upwardly conveyed until aligned with and discharged upon the surfaces of the oversize return chutes G^4. The main line of feed is along the feed chute G^5 and the oversize chutes G^4 return the oversize picked up by the buckets G^3 to the main line of feed along the chute G^5. The result is a closed crushing and screening circuit, the only normal escape from the circuit being through the screen.

However, it may happen, as in screening copper ore, that uncrushable masses of native copper may accumulate in the circuit. Similarly, uncrushable masses may accumulate in the crushing and screening of other materials. In order to permit the removal of such material I provide a rejector chute generally indicated as H which may be pivoted as at H^1 and which may be moved inwardly into the line of feed or delivery along the chute G^5, whereby the feed, or oversize, may be temporarily by-passed to the picking deck H^2, for the removal of the undesired particles. The deck H^2 may be pivoted as at H^3 whereby it may be dropped into the dotted line position as at H^4, after the picking has been completed. H^5 indicates a picking deck return chute, which delivers the particles on the deck back into the crushing and screening circuit.

Referring to Figure 1, I preferably employ a plurality of motors. I illustrate for example a primary motor O for the impeller, which is provided with a pulley O^1 slotted to receive a plurality of belts O^2 which serve to drive the pulley C^7 of the impeller shaft. A secondary motor O^3, through any suitable gear reducer O^4, may drive the sprocket O^5 and thereby the chain O^6 passing about the sprocket D^4 of the impeller housing.

It will be realized that whereas I have described and shown a practical and operative means for carrying on my invention or method, nevertheless it may be practiced by other and substantially different mechanisms. For example, whereas I have illustrated the impact members as rotating about a horizontal axis, it will be understood that some or all might be rotated about a vertical axis or axes. Whereas I have shown the impact members mounted upon a single rotating member, it will be understood that I might employ impact members mounted on one or two rotary members rotating about the same axis. Whereas I have shown a rotary outer reflecting surface E^2 of generally cylindrical shape, it will be understood that this outer reflecting surface may be of different shape, as for instance, conical, and may be segregated instead of smooth. It may be advantageous to move it, or it need not be moved. It will, therefore, be understood that my description and drawings are to be taken as broadly illustrative or diagrammatic rather than as limiting me to the precise mechanism shown for practicing my method.

The use and operation of my invention are as follows:

Broadly stated my method relates to the reduction of ore, rock or other material by disintegrating it by a series of impacts. In the particular device herein shown for carrying out my method, I disintegrate the ore or rock by a series of impacts with the striking or wearing plates B^3 which are fixed radially, or nearly so, to the impeller.

The impeller includes the circular disc B which is mounted centrally at the end of the spindle 1. The impeller and the impeller housing structure generally indicated as D rotate about a common axis, but are separately rotated and preferably at greatly different speeds. Material may be fed down the main feed chute G^5 and is thereby delivered into the space between the plate or disc B and the ring B^1 of the impeller. The material falls by gravity and preferably the chute is of sufficient length or the height of initial feed is sufficient to impart a very substantial gravity acceleration. Furthermore, the vanes of the impeller have a fan effect which tends to discharge air radially outwardly from the inner space of the impeller and this air movement further speeds the falling particles after they pass below the axis of rotation of the impeller. Therefore the material to be reduced is fed at a high rate of speed through the open end of the impeller on its downward path from the feed chute and, as it passes between the disc B and the ring B^1 into the line of movement of the striking plates B^3 each particle receives a disintegrating impact. The impeller revolves at a high rate of speed about its horizontal axis, at such a rate that in order to intercept an impact of all or substantially all of the falling particles, one, two or three or more of the members B^3 may be necessary. The feed chute G^5 may be steeply inclined, at an angle of 60 degrees more or less. The falling particles attain sufficient velocity relative to the velocity of the impeller striking plates B^3 to reach the path of the impeller plates before they are struck and the rates of rotation and the length of fall are preferably so timed and arranged that the particles make a full and complete contact with the faces of the striking plates B^3 rather than merely being struck by the top edges only.

The annular ring B^1 serves not only to support the ends of the struts but has the secondary function of confining and directing the passage of the broken ore or rock and also to create a definite air circulation through the impeller, to help carry the material or particles therethrough.

The reflector ring E with the plates E^2 surrounds and is concentric with the impeller, revolving about the same axis. After impact with the impeller striking plates B^3, the broken or partly disintegrated material instantly attains a high velocity, due to centrifugal force acting on it by the rotating impeller, and is thrown outwardly from the impeller and upwardly and outwardly against the wearing plate E^2 of the reflector ring. Centrifugal force, combined with the force of the air current set up by the impeller, act on the material in the same general outward direction, giving it a high velocity which directs the particles against the wearing plates E^2, resulting in a secondary reduction of the material.

There is some further reduction of particles of ore or rock caused by their striking each other in passing from the impeller to the reflector ring plates and vice versa. There is also some further reduction caused by particles bounding or rebounding from the reflector plates and again getting into the path of the revolving impeller striking plates.

For screening the disintegrated product I provide a circumferential screen or grizzly which rotates in unison with the impeller housing. The particles which are sufficiently reduced will pass through the screen or grizzly to any suitable conveying means. The oversize particles which cannot pass through the grizzly are picked up by the buckets G^3 and are thereby returned to the oversize return chutes G^4 and thus to the feed chute G^5.

As the result is a closed screening and disintegrating circuit, any non-reducible material should be removed from the circuit. For removing such material, such as tramp iron, steel, or native copper, or the like I may intercept the flow of the oversize return feed by the chute H, without shutting down the machine. It simply intercepts the oversize return and directs it to the picking table H^2. The uncrushable material is there picked and removed and the residue may be returned by tilting the table H^2 to deliver it to the return chute H^5. This ready means of removing uncrushable material makes unnecessary the use of a magnetic pulley for the removal of tramp iron or steel. Such foreign material can enter the machine without causing injury, because the clearance between the impeller and reflecting ring plates is several times the opening of other crushers making a product the same size. In other words, all that such uncrushable particles will do is to travel around the closed circuit without being disintegrated or screened. When there is sufficient accumulation of such particles to make it worth while, the rejector chute H is simply moved into position and such particles will then be delivered to the picking table H^2 for removal by picking.

The control of the intensity of the impact forces is a matter of importance. For a given diameter of impeller and a given speed, the intensity with which the partly reduced material is thrown out against the reflector ring, wear plates or the secondary impeller striking plates, by the impeller is controlled by the variation of the angle between a radial line drawn through the center of the impeller and some point on the plane of the face of the impeller striking plate. The intensity may therefore be varied by merely changing the angle of the faces of the members B^3 opposed to the material. The intensity may also be controlled by varying the speed of the impeller and by varying the diameter of the impeller. The combination of these varying factors makes possible a control of the breaking force to suit the requirements for breaking ores or rock of different hardness or size in order to get the greatest amount of work out of a given power input.

In defining the operation of my device I may employ the term "inner path" as the inner margin or inner face of the path described by the impact members as they run in their normal operation, the cylindrical surface defined by that part of the impeller members nearest their center of rotation. The outer path is the corresponding cylinder defined by the parts of the impellers farthest from their center of rotation. While I say "cylindrical" for purpose of illustration, it will be understood that I do not wish to be limited to any particular figure or shape, as the path might be conical or otherwise shaped.

Referring to the accompanying sketch, Figure 5, which is a cross section through the impeller striking members and breaker or reflector ring, I illustrate the mode of practicing my method by means of the structure elsewhere described of rotary impellers and a rotary reflector ring. S shows in general the position of any impeller striker face at the instant it impacts a portion of the feed as it falls into the path of the impeller striker members. M shows the shattered material contacting the impeller striker face at the instant of impact. S' shows generally the position of the impeller striker face as it begins to discharge the shattered material against the breaker and reflector ring. M' shows the shattered material on its way to the breaker ring. S'' shows generally the position of the impeller striker face when it has completed the discharge of the shattered material to the breaker ring. M'' shows the shattered material after its impact with the breaker ring with its resultant further shattering.

The material to be crushed or shattered is gravitally directed at a high velocity substantially into the path of the revolving impeller impact members from the steeply inclined chute G^5.

The initial or primary breaking takes place at S, as the impeller striker impacts and shatters the material on its fall through this crushing zone.

The secondary reduction takes place along the inner surface of the breaker and reflector ring and in a space along said ring as indicated by X, which space is located substantially in the upper half of the breaker ring. The partly shattered material M' is thrown centrifugally against the ring from the impeller striking members; the resultant impact further shatters and disintegrates this material. While still contacting the breaker ring, this twice shattered material M'' receives a bombardment of many crushing impacts from the material thrown against it by subsequent impulses of the impeller as these are delivered upward of thirty to fifty per second. The more finely reduced material is instantly blown aside by the air current set up from the impeller fan action, leaving only the coarser material in contact with the breaker ring to receive the subsequent impacts from the oncoming still coarser material M', which produces a crushing action on the material M'' as it is caught between the breaker ring and the material M'. By the prompt removal of the finer material from this crushing zone by the air current above mentioned, reduction of the material to extreme fineness is prevented. As this latter or secondary crushing takes place in substantially the upper half of the inner circle of the breaker and reflector ring, it will be readily seen that no bedding of the material in this crushing zone is possible. On the contrary, effective and efficient crushing results, because the material to be crushed is caught directly and squarely between the two crushing surfaces, namely; the breaker ring and the oncoming material, and is not cushioned by any bedded material.

The breaker and reflector ring, revolving slowly, constantly exposes a clean surface to the material in the area X, thus distributing the wear evenly over the entire surface of the breaker ring.

As the crushed material particles M'' fall or are reflected from the breaker and reflector ring much of it again enters the path of the impeller striking members and receives further shattering impacts. This crushed or shattered material subsequently finds its way to the screen or grizzly revolving with the breaker ring housing. The undersize material passes through the screen, and the oversize is returned by buckets, attached to the revolving grizzly or screen housing, which discharge this oversize material into the feed chute on top of the incoming feed, thus returning the oversize with the new feed to the crushing circuit.

I would call attention to the following: The position of X, that is, the secondary crushing zone, as indicated in the sketch, was determined by actual test. This position varies with the speed of the impeller, with the angle that the striking face makes with a radial line, and with the depth that the material penetrates into the path of the striking plates. In other words, this crushing area X can be, by the variation of any one of these factors, brought so that it will lie wholly in the upper half of the breaker ring, if desirable.

The particles to be crushed are dropped into the path of the impellers at a speed which is so related to the speed of the impellers that the particles to be crushed penetrate substantially entirely into the path of movement of the impellers or strikers before being impacted. The speed may vary. For example, there may be 35 impulses per second at 700 R. P. M. and 47 impulses per second at 950 R. P. M. These speeds and frequencies are merely illustrative, but are sufficient, in practice, to cause an efficient primary disintegration. The secondary disintegration takes place thereafter along the above mentioned zone X of Figure 5. Assume that the reflector ring is actually moving, say at the rate of $\frac{1}{16}$ of an inch for each impact. As the particles centrifugally delivered against the zone A rest against the surface for an appreciable time, in the neighborhood of half a second, before they begin to fall away by gravity. Particles already positioned against the ring receive a bombardment of the larger particles thrown outwardly by the impeller. As above mentioned, the fan action blows the fines away, preventing formation of a pad or bed which would interfere with crushing.

While I prefer to employ gravity as the means for imparting to the material the proper speed for carrying it into the primary crushing zone, it will be understood that I may practice my method with the employment of other means for accelerating the particles to be crushed. I may, for example, project a stream of particles into the crushing zone by any suitable mechanical means, conveyors, projectors or the like.

As specific examples of variant means for practicing my method, I illustrate, in Figure 6, a vertical rotor P having a plurality of impact members P^1 and a chute P^2 adapted to drop the material to be crushed into the path of these impact members. P^3 is a reflector member, also rotating about a vertical axis, and adapted to receive the impacts of the material centrifugally delivered by the impact members. P^4 is any suitable discharge chute.

I claim:

1. The method of multiple stage impact crushing which includes, first, projecting by gravity, and along a generally defined path, a stream of particles to be crushed; moving transversely through said path a succession of primary impact members, at such speed and momentum as will cause adequate crushing impacts to the dropping particles of said stream; maintaining the velocity of the particles fed into the primary crushing zone formed by the intersection of the path of feed and the path of the impact members sufficiently high, in relation to the speed and spacing of the succession of impact members, to carry substantially each particle of the stream fully into the path of the impact member which impacts it, whereby such particle is positioned to be squarely impacted by the impact face of such impact member; directing the impacted particles outwardly, as the result of said impact, from the primary crushing zone; terminating the outward flight of the impacted particles by a secondary crushing impact at a secondary crushing zone removed from the primary crushing zone and thereafter gravitally withdrawing the broken particles through a zone of withdrawal remote from the primary impact zone.

2. The method of impact crushing which includes, first, projecting by gravity, and along a generally defined path, a stream of the particles to be crushed; moving transversely through said path a succession of impact members, at such speed and momentum as will cause adequate crushing impacts to the dropping particles of said stream; maintaining the velocity of the particles fed into the crushing zone formed by the intersection of the path of feed and the path of the impact members sufficiently high, in relation to the speed and spacing of the successive impact members, to carry substantially each particle of the stream fully into the path of the impact member which impacts it, whereby such particle is positioned to be squarely impacted by the impact face of such impact member, and thereafter withdrawing the broken particles from the crushing zone.

3. A method of impact crushing which includes moving a succession of impact surfaces through a crushing zone, projecting downwardly in response to gravity an unconsolidated stream of freely falling particles, and directing said stream transversely through said crushing zone; proportioning the speed of said impact surfaces and said particles such that the time required for a single particle to pass through said zone is generally the same as the time interval between the passage of successive impact surfaces through said zone, whereby to permit all of said particles to enter the spaces between successive impact surfaces an extent sufficient to insure a full face primary crushing impact; and causing said particles in response to said primary impact to travel laterally without obstruction entirely out of said primary crushing zone.

4. A method of impact crushing which includes moving a succession of impact surfaces through a crushing zone, projecting downwardly in response to gravity an unconsolidated stream of freely falling particles, and directing said stream transversely through said crushing zone; proportioning the speed of said impact surfaces and said particles such that the time required for a single particle to pass through said zone is generally the same as the time interval between the passage of successive impact surfaces through said zone, whereby to permit all of said particles to enter the spaces between successive impact surfaces an extent sufficient to insure a full face primary crushing impact; causing said particles in response to said primary impact to travel laterally without obstruction entirely out of said primary crushing zone; and terminating the lateral flight of said particles by a secondary crushing impact at a secondary crushing zone removed from said primary crushing zone.

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