

June 30, 1942.

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2,287,799

HAMMERMILL

Filed June 13, 1939

3 Sheets-Sheet 1

Fig. 1.

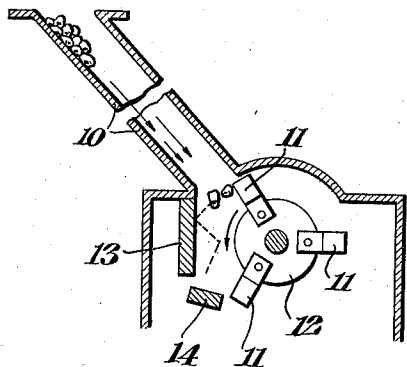


Fig. 2.

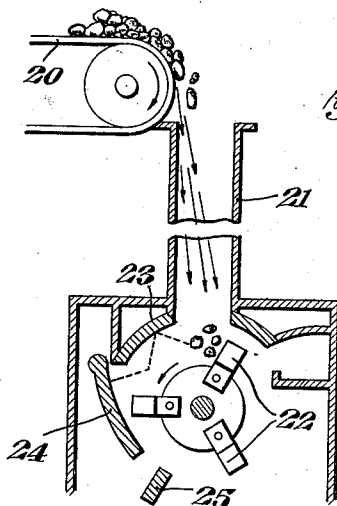


Fig. 4.

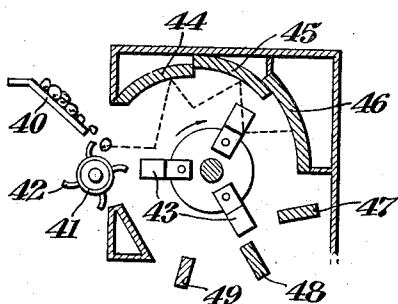


Fig. 5.

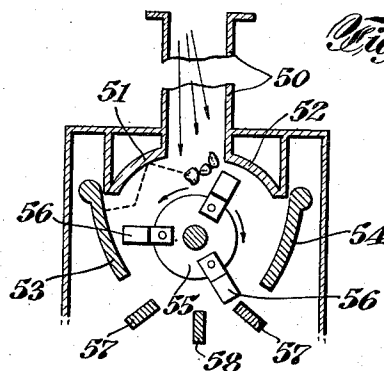
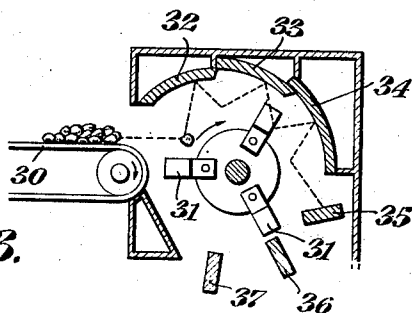


Fig. 3.



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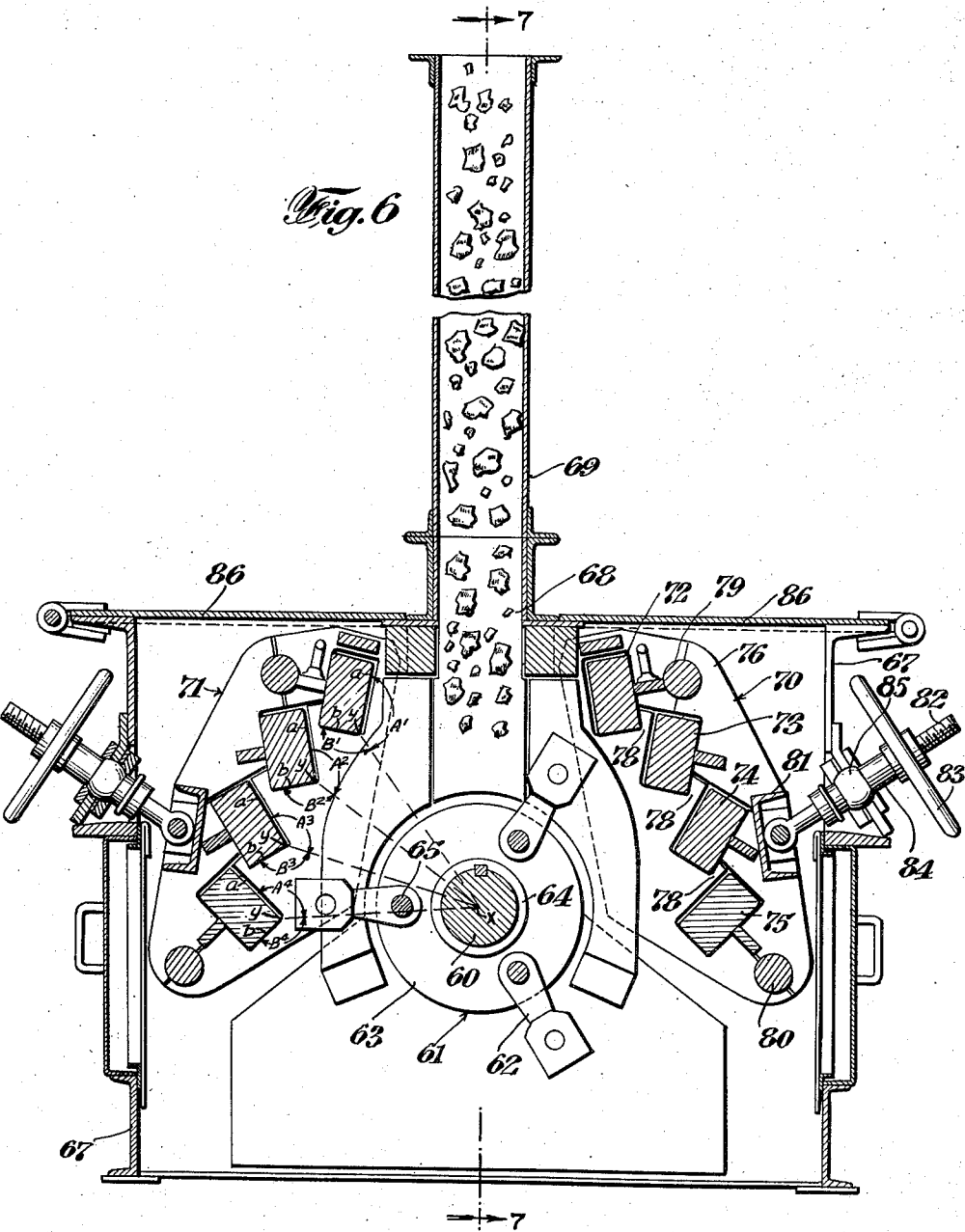
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3 Sheets-Sheet 2



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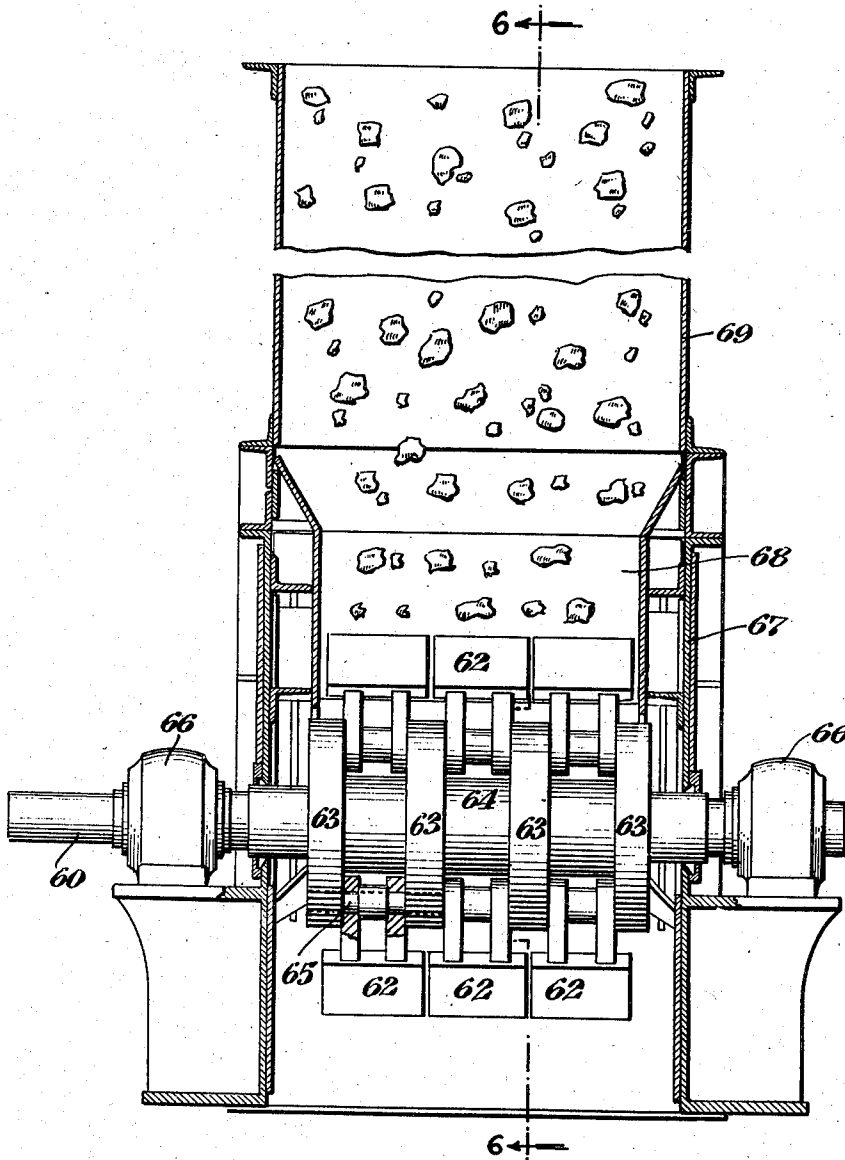


Fig. 7.

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HAMMER MILL

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Application June 13, 1939, Serial No. 278,974

12 Claims. (Cl. 83-46)

This invention relates to hammermill crushers, and particularly to such crushers of the type using pivoted or rigid hammers to impact and fracture the material.

The object of the invention is the provision of a hammermill crusher which is simple in construction and efficient and inexpensive in operation.

Another object of the invention is the provision of a hammermill crusher coordinating the movement of the hammers and material so that a full impact is developed between them not relying on glancing blows which makes it impossible to utilize the full inertia resistance of the particles against the hammer surfaces.

Still another object of the invention is the provision of a hammermill crusher which dispenses with the screening cages and performs all the reduction of material by a series of impacts.

Further objects and advantages of the invention will appear from the following description considered in connection with the accompanying drawings in which:

Figs. 1-5 inclusive are schematic vertical sectional views of hammermill crushers illustrating various embodiments of my invention;

Fig. 6 is an end view in vertical section of a crusher illustrating a modification, the view being taken substantially along the line 6-6 of Fig. 7; and

Fig. 7 is a side view in vertical section of the crusher of Fig. 6, the view being taken along the line 7-7 of Fig. 6.

In the system of this invention the hammers and the material are so related at impact that effective crushing forces are developed between them. The desired speed of the rotor is maintained and the material is caused to enter well within the hammer circle before it is met by the hammer surface. This is preferably accomplished by propelling or dropping the material at sufficiently high velocity into the hammer circle that the material enters in front of the hammers a distance at least sufficient to carry the average sized piece fully within the hammer circle. For instance, the velocity may be sufficient to cause the full-sized pieces of material entering inward into the leading half of the space between successive hammers to pass inward within the hammer circle a distance at least equal to the average radii of such full-sized pieces at the time they are struck by the succeeding hammer. As a consequence all the pieces of material, including the full-sized pieces, entering in the first half of the distance between the hammers will receive a full

initial impact and with the lines of impact passing through their centers of gravity, and substantial proportions of the pieces entering in the second half of the distance between hammers will also receive this full initial impact. Thus the great majority of the pieces representing the greater part of the material will be struck directly by the hammers traveling at full speed and a high crushing force will be developed to effect the initial breakage of the material. The pieces instead of flying off centrifugally will be dealt a full blow and projected substantially tangentially with high velocities along the line of the impact, dashing them against the surfaces of the cooperating breaker plate and back between the hammers on the rebound.

In Fig. 1 the material is fed to the hammers down an inclined chute 10 having the desired length. The material is struck and fractured by one of the hammers 11 on the rotor 12 and projected in a general tangential direction against the primary breaker plate 13, the fragments being there fractured and reflected by rebounding back into the hammer circle and again struck by the hammer and further fractured and driven against the annularly arranged anvil bar or kick-off plate 14 for further disintegration and reduction. After impinging upon the kick-off plate the fragments pass out of the hammermill at its bottom, there being no cage of screen bars such as are present in other hammermills for reduction of the material by attrition between the hammers and the screen bars.

In Fig. 2 a timed supply belt 20 is used to deliver the material at a predetermined elevation, such as ten feet, and dropping the material freely and centrally through feed chute 21 into the hammer circle, whereupon the hammers 22 will squarely hit the pieces, fracture them and project the fragments directly against the breaker plate 23 with rebound at right angles back into the hammer circle and then against the subsequent breaker plate 24 and kick-off plate 25. The angle of the kick-off plate is generally radial to the hammer circle, but may be adjusted and varied as desired.

In Fig. 3 a high speed belt 30 properly loaded with material projects the pieces substantially horizontally into the circle of hammers 31 so that the fragments are driven upward against the breaker plate 32 and rebound to the hammers and against subsequent breaker plates 33 and 34 to the final kick-off plates 35, 36, 37 as shown.

In Fig. 4 the material is run down the inclined feed 40 to the rotor 41 having projector blades

42, throwing the material horizontally into the circle of hammers 43 to be impacted and have its fragments driven and rebounded against the breaker plates 44, 45, 46 and then to the kick-off plates 47, 48, 49.

In Fig. 5 the construction is symmetrical and reversible and involves a central vertical chute 50 of predetermined height with fixed breaker plates 51, 52 on opposite sides and adjustable breaker plates 53, 54 and kick-off plates 57, 58, as shown. The rotor 55 with hammers 56 may be run in either direction so that when one side of the hammers becomes worn reversal of rotation will transfer the wear to the other side without removing and replacing the hammers.

In each of the constructions of Figs. 2-5, as in the construction of Fig. 1, screen bars may be dispensed with as shown.

Referring to Figs. 6 and 7 the crusher has a horizontal shaft 60 carrying rotor 61 with pivoted hammers 62. The rotor discs 63 are regularly spaced along the shaft by suitable spacers 64 and have several rods 65 (three in the system illustrated) extending longitudinally through suitable holes in the discs at regularly spaced intervals around the shaft and equidistant therefrom. Between adjacent discs 63 each rod 65 has a hammer pivoted thereon so that each space between discs contains a series of pivoted hammers 62 (three as illustrated) all rotating in the same planes. As many series of hammers 62 may be employed as desirable, three such series being shown in the system illustrated.

The shaft 60 is supported upon bearings 66 and is rotated by a reversible motor (not shown) at a speed producing a peripheral speed of the hammers in either direction sufficient to maintain the hammers in a nearly radial position under the impact.

The hammer system is contained within a housing 67 which is symmetrical about a vertical plane through the axis of the hammer system.

Positioned centrally above the hammer system is the entrance opening 68 for the uncrushed material, the opening being substantially rectangular in cross section with the smaller side relatively narrow circumferentially so that the incoming material is struck by the hammers in a narrow zone at the highest point of hammer travel. Preferably a vertical feed chute 69 connects with the entrance 68, the chute being of sufficient height to cause the full sized pieces of material entering inward into the leading half of the space between successive hammers to pass inward within the hammer circle a distance at least equal to the average radii of such pieces at the time they are struck by the succeeding hammer.

The speeds of the hammers and material are such that the fragments of material leaving the hammer surfaces after the initial impact are projected substantially tangentially with high velocities along the line of the impact over the upper end of anvil structure 70 or 71, depending upon the direction of rotation of the hammers.

Each anvil structure 70, 71 comprises a plurality of parallel anvil bars 72, 73, 74, 75, mounted in pivoted end plates 76 positioned at their ends. The anvil bars are rectangular in cross section, and are positioned serially in an arc beyond the hammer circle with their edges overlapping while leaving openings 78 between adjacent anvil bars, the bars being tipped at different angles relative to the horizontal so that the face of each bar is substantially perpendicular to the angle at

which the fragments of material are projected against the respective bars. In the construction shown this is obtained by having impact faces *a* of the anvil bars 72, 73, 74 and 75 inclined at the angles A^1 , A^2 , A^3 and A^4 , respectively, (each approximately 135°) with respect to the radii *x*, *y* from the axis *x* of the rotor 61 to the inner edges *y* of the respective bars. This position of the rectangular cross section anvil bars inclines their side faces *b* at angles B^1 , B^2 , B^3 and B^4 , respectively, (each approximately 135°) with respect to the same radii but on the side of the radii opposite from impact faces *a*. The end plates 76 are secured together by rods 79 and 80 and by an angle member 81 to form a unitary anvil structure. This anvil structure is pivotally supported near its top to the housing 67, rod 79 in this case serving also as the pivotal support.

Suitably connected to the angle member 81 is a threaded rod 82 which extends outwardly through the housing 67. An adjusting handwheel 83 is threaded upon rod 82 and engages the upper end of a sleeve 84 through which rod 82 passes and which is secured to the housing by a suitable ball and socket joint 85. By adjusting the handwheel the anvil assembly is swung closer to or farther away from the hammer circle around pivot 79. Between the limits of motion of the anvil assembly the displacement of anvil bar 72 is small and is progressively larger for the succeeding anvil bars.

The anvil bars are positioned substantially in the upper half of the crusher, that is, the lowermost anvil bar is positioned substantially on the level with the shaft. The hammermill has no cage or screen bars, being open below the final anvil bar 75 so that the material passes downward and out of the crusher without being subjected to attrition.

The anvil assemblies are quickly removable as a unit for replacement or turning of the anvil bars by raising the unit upwardly through the hinged roof plates 86 in housing 67.

The anvil bars are reversible front to back and end to end so that each bar has four effective wearing surfaces.

The clearance 78 between anvil bars provides a passageway for the material in the corner of the anvil faces. This material thus removes itself or drains from the anvil bars so that such material does not accumulate on the anvil surfaces and thus impair the operation of the crusher. This drainage is particularly advantageous when reducing wet material.

The elimination of the cage screen in addition to reducing the wear of the hammers and screen bars also avoids other difficulties such as plugging of the screen openings, particularly when wet material is handled, and sudden changes in load such as occur when oversize pieces get into the pinch points.

In operation, the feed enters centrally and directly over the rotor. The height of feed chute is proportioned so that the ore or stone or other material penetrates the hammer circle well in front of the hammers. A hard, smashing, head-on hammer blow, in midair, projects the material violently against the top anvil bar 72. The finer finished material escapes below while the anvil bar deflects the larger pieces back into the hammer circle and the operation repeats, the material being projected against the anvil bars 72, 73, 74 and 75 in succession so that the material is subjected to a succession of violent impacts before passing out of the crusher. The

larger the pieces surviving the first hammer impact, the oftener they rebound between hammers and anvil bars for further reduction.

This crusher is capable of handling satisfactorily a wide range of sizes and types of material. The variables are the hammer speed, the height of feed chute, the number and shape of the hammers and the diameter of the hammer circle, and the adjustment, number, size, angle setting and arrangement of the anvil bars. All these give desirable operating flexibility and enable the crusher to obtain economically a wide range of reduction ratios for a wide range of sizes and types of material.

As an example of the large reductions obtainable, the feed is capable of reducing from minus 6", and in some cases up to 10", to minus 1/4" or minus 1/8". By suitable readjustments of the same machine it may be made to reduce 1" or 3/4" or 5/8" feed to sand.

In all the reductions the output material has a high percentage of cubes and a low percentage of spalls.

The feed may be stone, ore, abrasive clinkers, gravel, dolomitic limestone, brittle or porous refractories or other natural or artificial materials.

A typical peripheral speed for the hammers in a machine of this character is a speed of 9900 feet per minute.

It has been found that with the harder materials the anvil assembly is preferably adjusted to a position near its outer limit while with softer materials the anvil assembly is adjusted to a position nearer its inner limit. From this observation, it is believed that an important action of the adjustable anvil assembly is to vary the length of the path of travel of the material to compensate for the different speeds with which materials of different hardness are projected by the hammers and rebound from the anvils, while insuring that the material is always directed back into the hammer circle to meet squarely an oncoming hammer. In other words, the relative angularity of the anvils and the adjustment of the assembly provides a proper timing of the impacts with the hammers and anvils throughout the path of the material between the hammers and anvils alternately.

This application is a continuation-in-part of my application for Hammermill, Serial No. 712, filed January 7, 1935.

The term "high velocity," as used in certain of the claims for describing the velocity with which the uncrushed material is fed into the hammermill, is a velocity at the hammer circle sufficient to cause the pieces entering inward into the leading half of the space between successive hammers to pass inward within the hammer circle a distance at least equal to the average radii of the full sized pieces at the time they are struck by the succeeding hammer.

I claim:

1. A hammermill for frangible material comprising a rotor, a plurality of hammers carried by said rotor imparting a peripheral speed of over three thousand feet per minute to the hammers, a feed projecting material radially inward along a straight line into the hammer circle at a speed causing the full-sized pieces of material entering into the leading half of the hammer interval to pass within the hammer circle a distance at least equal to the average radii of such pieces so that the pieces are fully impacted and the fragments projected tangentially at the point of impact, and a plurality of separate anvil bars

constituting the sole stationary means for impacting and fracturing the material as it passes through the mill and including an initial anvil bar having its impact surface extending inward toward the hammer circle and inclined away from the line of travel of the entering material to squarely receive and reduce said fragments from the initial hammer impact and reflect the pieces back into the hammer circle, and a succeeding anvil bar having its impact surface extending inward toward the hammer circle and inclined toward the line of the entering material to squarely receive and reduce the fragments reflected into and reduced and re-projected by the hammers, the fragments passing back and forth between the hammers and anvils being reduced to predetermined size by impact and discharged without substantial attrition between the hammers and stationary surfaces of the mill.

2. In crushing apparatus of the type having a hammer system rotating about a horizontal axis and having the material fed into the hammer circle of the system from the outside of the hammer circle and then projected by the hammers against an anvil structure position outside the hammer circle, the improvement therein in which (a) the feeding means directs the pieces of material at high velocity substantially radially inward toward the axis of rotation of the hammer system so that the hammers will squarely hit a large proportion of said pieces, fracture them by impact and project the fragments outward substantially tangentially to the circles of impact, and (b) the anvil structure has a plurality of anvil surfaces successively arranged around the hammer circle each inclined for a substantial part of its working surface approximately 135 degrees with respect to radii thereto from the axis of the hammer system and each at such distance from the hammer circle as to substantially squarely intercept the fragments projected by the hammers and direct the rebound of the fragments back into the hammer circle to be struck another hammer blow and projected against a later one of said anvil surfaces.

3. Apparatus as set forth in claim 2 in which each anvil surface is substantially flat with the inner edge of each of said anvil surfaces inclined approximately 135 degrees with respect to the radius thereto from the axis of the hammer system, and with the inner portion of the anvil surfaces slightly overlapping the outer portion of the next successive anvil surface.

4. Apparatus as set forth in claim 2 having the anvil surfaces provided on members which are spaced relative to each other to provide openings at the outer portions of the anvil surfaces through which outwardly scattering fragments may pass.

5. Apparatus as set forth in claim 2 in which an auxiliary impact surface is provided between successive anvil surfaces, with each auxiliary impact surface positioned at an angle which is of the order of 135 degrees with respect to the radius from the axis of the hammer system to the inner end of such auxiliary impact surface.

6. In hammermill crushing apparatus having a hammer system with nearly radial hammer faces, the combination of feeding means directing the pieces of entering material at high velocity substantially radially inward toward the axis of rotation of the hammer system so that the hammers will squarely hit a large majority of said pieces, fracture them by impact and project the fragments outward substantially tan-

gentially to the circles of impact, and a cooperating anvil structure intercepting the hammer-projected material comprising a plurality of anvil bars of substantially rectangular cross section positioned successively in an arc with the front face of each anvil bar positioned to intercept the hammer-projected material and so tipped that the angle between the bar faces is substantially bisected by a radius from the axis of the hammer system, each successive impact face being spaced from the adjacent edge of the preceding anvil bar, so that the material is crushed substantially entirely by fracturing impacts alternately against the hammers and anvil bars and is discharged from the apparatus directly from the last impact.

7. Apparatus as set forth in claim 6 in which the anvil structure includes interconnected end plates in which the ends of the anvil bars are positioned, and means pivotally mounting the end plates about an axis parallel to the axis of the hammer system so as to provide a unitary adjustment of all the anvil bars relative to the hammer system.

8. In hammermill crushing apparatus having a hammer system with nearly radial faces, the combination with feeding means directing the pieces of entering material in a falling stream at high velocity substantially radially inward toward the axis of rotation of the hammer system in a confined narrow zone at the highest point of hammer travel so that the hammers will squarely hit a large majority of said pieces, fracture them by impact and project the fragments outward substantially tangentially to the circles of impact, and a cooperating anvil structure, which intercepts the hammer-projected material and forms the sole stationary means for substantially impacting and fracturing the material as it passes through the apparatus, comprising a plurality of anvil surfaces which are successively arranged along a generally circular arc about the axis of the hammer system and substantially within a quadrant of said arc extending in the direction of hammer rotation from the material-entry zone and respectively inclined with respect to said arc so as to substantially squarely intercept the hammer-projected fragments and direct their rebound into the hammer circle, the said anvil surfaces being positioned close enough to the hammer circle to cause a large proportion of the rebounding fragments to re-enter the hammer circle yet not close enough to cause substantial attrition of the material between the hammers and the inner edges of said anvil surfaces, so that the material is crushed substantially entirely by fracturing impacts alternately against said hammers and anvil surfaces and then passes directly to the output of the apparatus.

9. Apparatus as set forth in claim 8 in which the hammer system is rotatable in either direction and in which a similar anvil structure is similarly provided for the opposite direction of hammer rotation, so that the anvil structures serve alternately for opposite directions of rotation of the hammer system and the product resulting in either case from the impact action of the hammers and anvil surfaces on the material passes directly downward and outward through an obstruction-free path in the lower half of the apparatus.

10. Apparatus as set forth in claim 8 in which the anvil structure consists of a plurality of anvil bars of substantially rectangular cross section, of interconnected end plates in which the ends of the anvil bars are positioned, and of means pivotally mounting the end plates in their upper region about an axis parallel to the axis of the hammer system so as to provide a unitary adjustment of all the anvil bars with respect to the hammer system wherein a given angular adjustment of the anvil structure imparts substantially more displacement to the bottom anvil bar than to the top anvil bar.

11. In an impact crusher and feeding means therefor, a rotor and means for rotating it about a generally horizontal axis, said rotor including a hub and a plurality of impact members outwardly extending therefrom, and feeding means for said rotor including a belt and a plurality of pulleys about which said belt passes, said pulleys being mounted for rotation about horizontal axes, one of said pulleys being located adjacent the periphery of movement of the impact members of said rotor, and means for simultaneously driving said rotor and said belt at speeds adapted for projection of material from said belt directly into the path of movement of said impact members whereby such particles are positioned to receive a full face crushing impact, the impact member spacing being correlated with the speed of the feed conveyor.

12. In crushing apparatus of the type having a hammer system rotating about a horizontal axis and having frangible material such as stone and the like fed into the hammer circle of the system from the outside of the hammer circle and then projected by the hammers against an anvil structure positioned outside the hammer circle, the improvement therein in which (a) the feeding means directs the pieces of material at high velocity substantially radially inward toward the axis of rotation of the hammer system so that the hammers will squarely hit a large proportion of said pieces, fracture them by impact and project the fragments outward substantially tangentially to the circles of impact, and (b) the anvil structure is the sole structure cooperating with the hammer system for effecting substantial reduction of the material and has a plurality of anvil surfaces successively arranged around a part of the hammer circle in the upper half of the crusher with the final, lowermost anvil surface positioned substantially on the level with the axis of the hammer system and with each anvil surface inclined for a substantial part of its working surface approximately 135° with respect to radii thereto from the axis of the hammer system and each at such distance from the hammer circle as to substantially squarely intercept the fragments projected by the hammers and direct the rebound of the fragments back into the hammer circle to be struck another hammer blow and thereby projected against any later one of said anvil surfaces without substantial attrition between the hammers and the anvil surfaces, whereby the said improvement causes the output material to consist of a relatively high percentage of fractured particles of desired size and shape and a relatively low percentage of fines.

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