

Nov. 28, 1933.

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1,936,742

APPARATUS FOR COMMINUTING MATERIALS

Filed Aug. 4, 1927

4 Sheets-Sheet 1

Fig. 1.

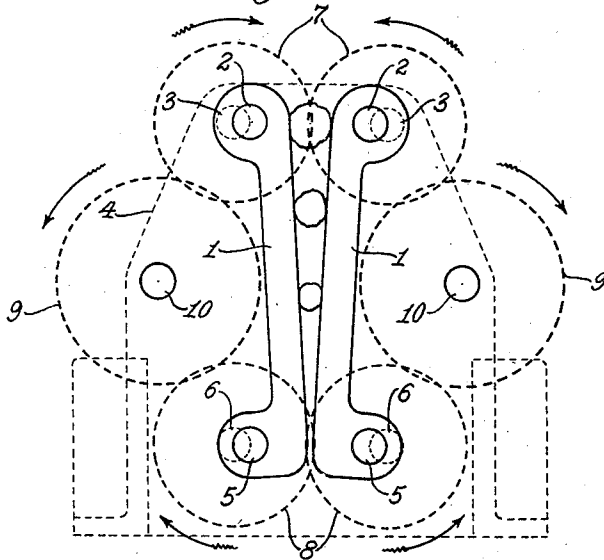


Fig. 2.

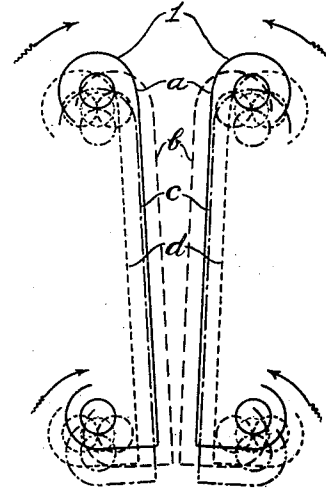


Fig. 3.

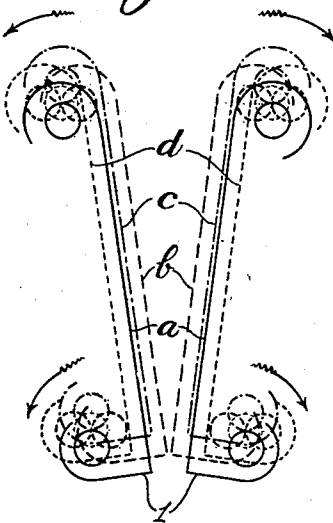
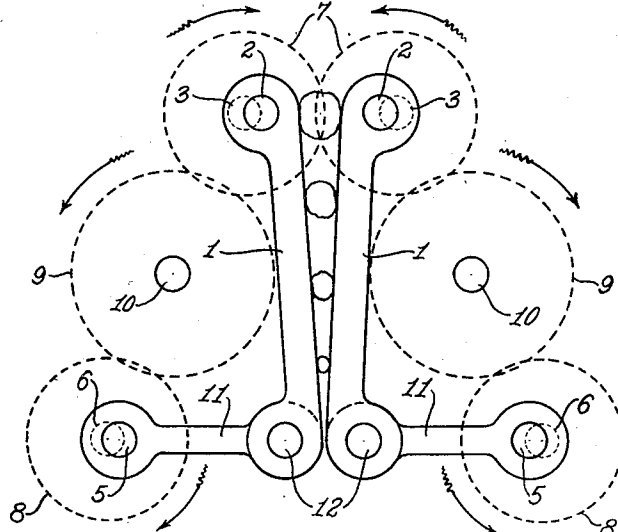


Fig. 4.



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Fig. 5

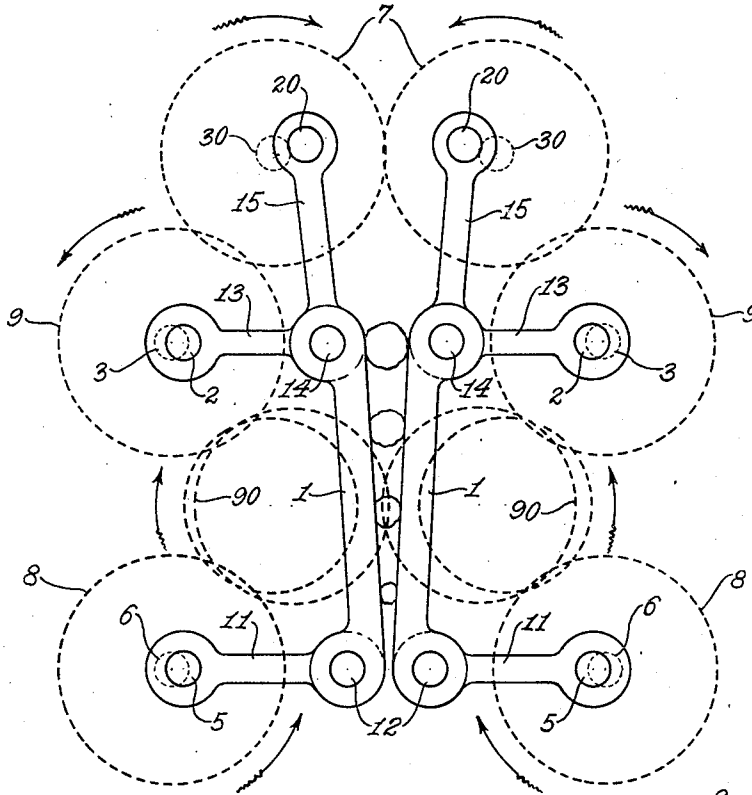


Fig. 6.

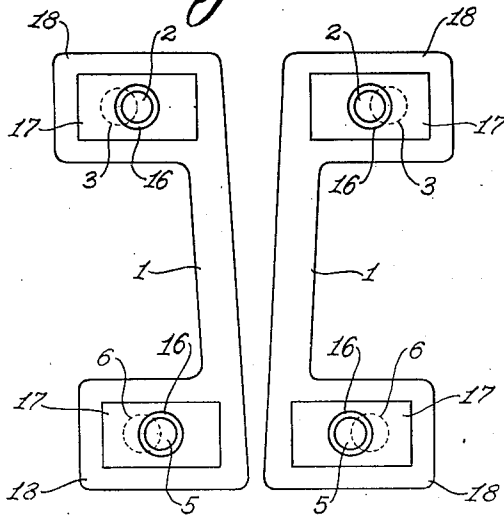


Fig. 7.

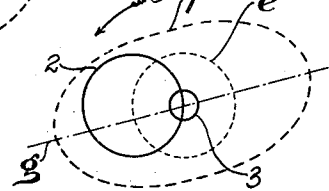
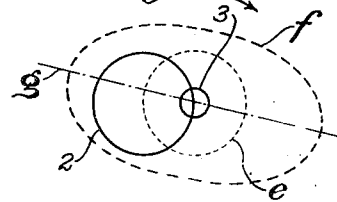


Fig. 8.



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Fig. 9.

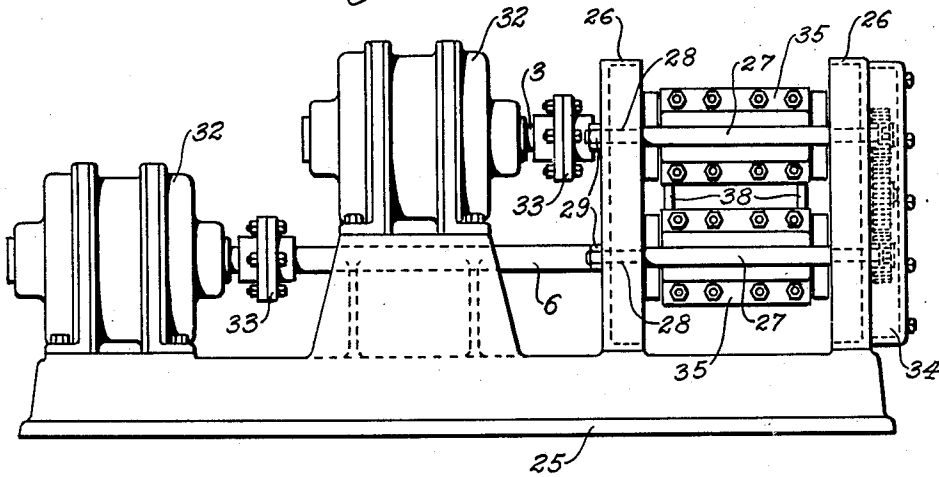
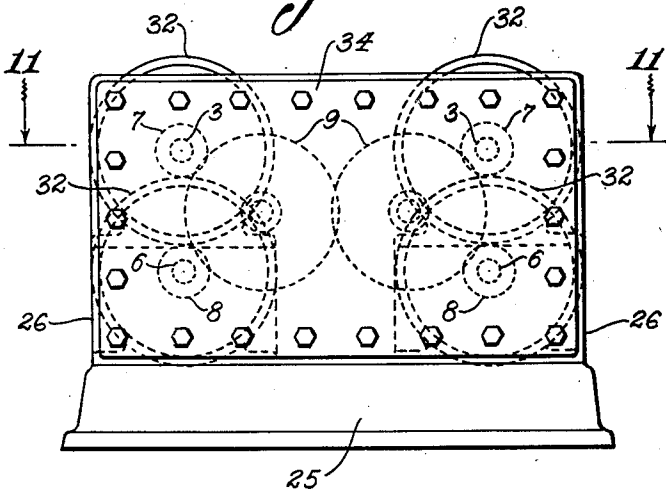


Fig. 10.



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Fig. 11.

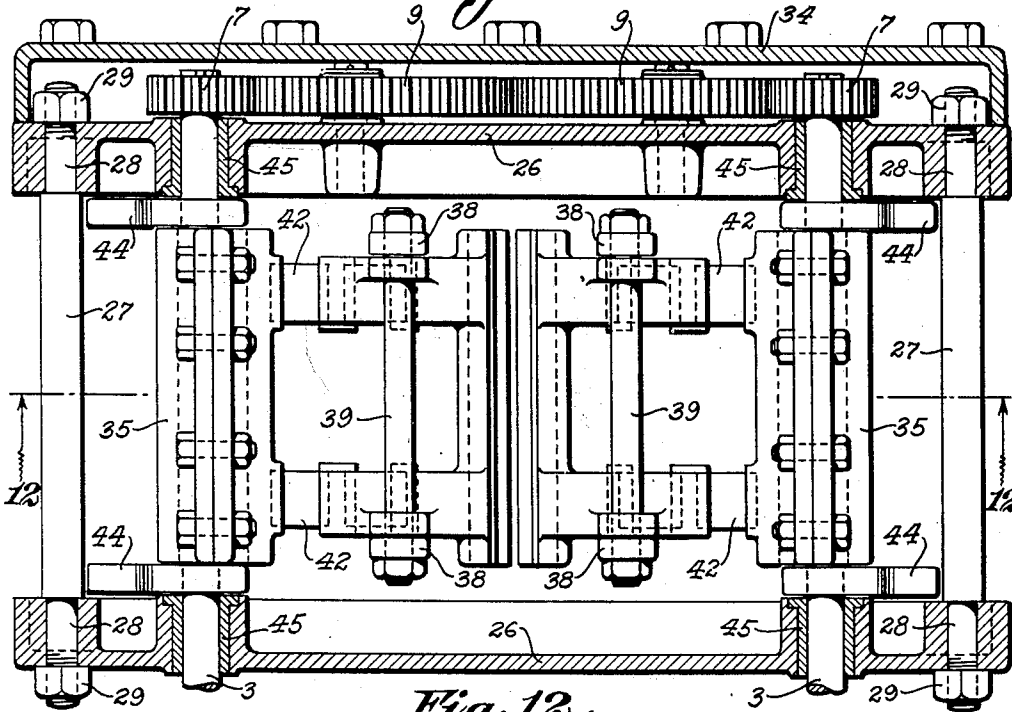
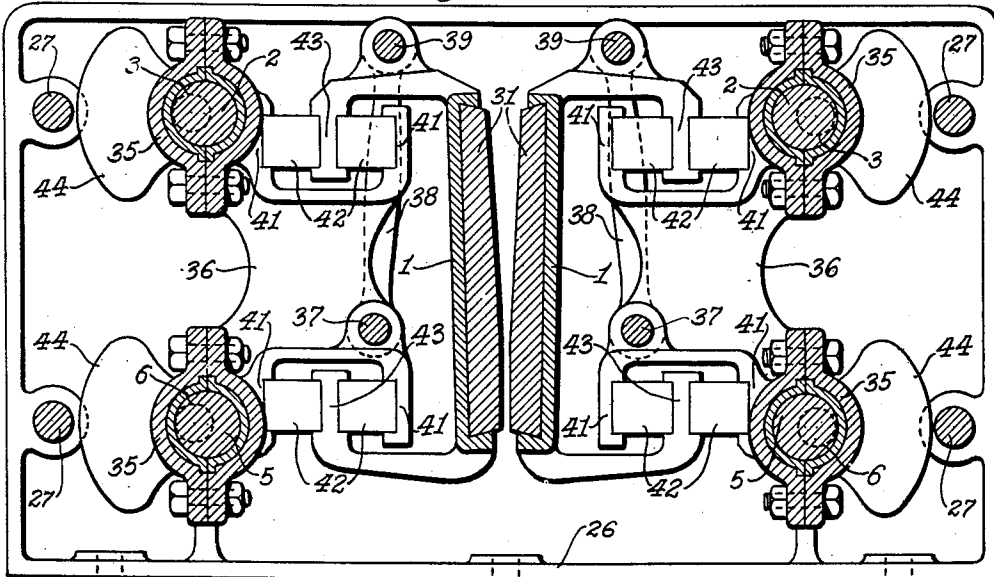


Fig. 12.



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UNITED STATES PATENT OFFICE

1,936,742

APPARATUS FOR COMMUNUTING
MATERIALS

Floyd S. Youtsey, Collinsville, Ill.

Application August 4, 1927. Serial No. 210,507

9 Claims. (Cl. 83—53)

This invention relates to the art of comminuting materials, and more particularly hard and friable materials, such as ore, rock, etc.

A piece of material which is capable of being crushed or pulverized is more or less friable. When such a material is compressed between two surfaces, the reduction can be carried on to a certain limit when it begins to "pack"—that is, it fractures and breaks into smaller particles, and a point is reached where these particles "pack" and are obstinate to further compression—if the pressure is great enough, the particles may again be formed into a compact piece. The degree of "packing" depends upon the nature of the material being comminuted; the "packing" point may be reached when the compression is from one-half to three-fourths of the piece being reduced; however, this ratio varies with the nature of the material being comminuted. In the art, the terms "crushing" and "pulverizing" are generally used as more or less definite divisions of the general term "comminuting"; the term "crushing" is generally applied to the reduction in size of larger pieces, while "pulverizing" is generally applied to the reduction to very fine particles.

Where a material is reduced by the action of relatively approaching and receding jaws or elements while the material flows therebetween, the material flow is generally produced by gravity. However, the force of gravity is a fixed force; accordingly, the flow or progress of the material through the machine is also fixed. In view of this fact, the reduction of material is not subject to such control as is desired, and on account of this fact, the capacity of any given machine is limited and determined.

The conditions and limitations encountered in the comminution of materials can be appreciated by a brief description of the principles involved. Let us assume that a piece is to be crushed in a jaw crusher, in which the jaw faces incline upwardly and outwardly and approach and recede. Let us also assume that the piece can be compressed or crushed to one-half of its thickness. As this piece is so reduced, the resulting aggregate is released, allowed to separate and drop down into the narrowing space between the jaws; the largest piece of the resulting aggregate will now have a thickness equal to one-half of the original. At the second compression, this half size piece is reduced one-half again, or to one-fourth of the original size, and the resulting aggregate is again released, allowed to separate and drop between the reduced space between the jaws. At the third compression, the largest piece of this aggregate is again reduced one-half, or to one-eighth of the size of the original, and so on, until the resulting particle

reaches the desired size or drops through the space between the jaws at the bottom.

Now, it can readily be seen that the capacity and operation of such a crusher are limited by the fall of the progressively reduced pieces between the jaws, and since the fall is dependent upon gravity, which is a constant, a point will soon be reached where the flow of the material will reach a certain maximum beyond which it cannot go, irrespective of the speed of the movement of the jaws. The conditions and limitations encountered in the crushing or reduction of large pieces are, however, different from those encountered in the pulverizing or reduction of small particles.

In pulverizing small particles, the force of gravity is not sufficient to permit efficient and speedy reduction. This is because the particles cannot drop a sufficient distance between successive compressions when gravity is solely relied upon to promote the movement of the particles downwardly, at the time when the jaws recede for a sufficient distance, to cause these jaws to secure maximum reduction when they again approach. A point is, therefore, soon reached where the speed of approach and recession results in no further appreciable increase in the flow of the material.

On the other hand, in the crushing or reduction of larger particles, the flow of the material under the action of gravity is too fast for efficient crushing. In such crushers, the angle between the faces of the opposed crusher jaws is necessarily made large on account of the large ratio of reduction which takes place as a given piece passes between the jaws. When the jaws approach to compress a piece which has just entered therebetween, so as to reduce the same to, say, one-half of its original size, and as these jaws recede, the reduced pieces of the aggregate will fall a definite distance under the action of gravity. The result is that these pieces will tend to fall so far that the next reduction obtained upon approach of the jaws will go beyond the "packing" point. For example, where the "packing" point of a given material is reached when the reduction is to more than one-half of the size of the original piece, the fall of the previously reduced pieces between the jaws when they recede may be such that the subsequent approach of the jaws may tend to reduce them to more than one-half of their size, or more than one-fourth of their original size. Accordingly, "packing" is liable to take place. Moreover, the coarser pieces drop between the jaws so fast during each recession that there will not be space enough in the narrowing zones to take the material, and as the coarser pieces are continually crowded into these zones, the finer pieces may not be able to

get out, so that "packing" will take place also in this manner.

One of the objects of this invention, therefore, is to provide a process and apparatus for comminuting materials, in which the operations are so controlled and the fall of the material between the crushing element so modified that "packing" will be prevented.

Another object is to provide a process and apparatus of the character referred to, whereby the progressive reduction may be secured up to the limits of the requirements or the limits of mechanical possibilities.

Another object is to provide a process and apparatus of the character referred to, in which the material is reduced by impact and so as to reduce the strain and wear on the apparatus and its operating connections.

One of the features of this invention resides in the fact that the approaching or receding jaws, between which the material flows in order to reduce it, are moved along the path of the material flow while they are approaching or receding. In accordance with one embodiment of this invention, the jaws or elements are each moved in an annular path, one component of each path being along the material flow, while the other components of the paths approach and recede relatively.

Another feature of this invention resides in the fact that the jaws and elements are moved, during the operation of pulverizing or reducing smaller particles, in a direction opposed to the material flow while they are receding or apart, so that the action of gravity in permitting flow is augmented.

Another feature of this invention resides in the fact that the jaws and elements are moved, during the operation of crushing or reducing large pieces, in a direction opposed to the material flow while they are approaching or together, so that the action due to gravity is lessened.

Another feature of this invention resides in the fact that the elements or jaws are operated to strike the material flowing therebetween, in order to reduce the same by impact. In accordance with one embodiment of this invention, the elements are so related or connected to their operating means or mechanism as to move relatively thereto, in order to provide mechanical hysteresis between the elements and their operating connections, whereby the former will lag behind the latter.

Further objects and features will appear from the detail description, taken in connection with the accompanying drawings, in which—

Figure 1 is a view, somewhat diagrammatical in form, illustrating one embodiment of this invention;

Figure 2 is a similar view, showing the operation of the elements when pulverizing or reducing smaller particles;

Figure 3 is a similar view, showing the operation of the elements when crushing or reducing larger particles;

Figure 4 is a view similar to Figure 1, showing another embodiment of this invention;

Figure 5 is a similar view, showing still another embodiment of this invention;

Figure 6 is a similar view, showing means for securing lag or hysteresis between the operating connections and the elements;

Figures 7 and 8 are diagrammatical views, showing the effect of the hysteresis or lag when operating, respectively, to pulverize or crush;

Figure 9 is a side elevation of an apparatus illustrating a practical embodiment of this invention;

Figure 10 is an end elevation of Figure 9;

Figure 11 is a section on the line 11—11, Figure 10; and

Figure 12 is a section on the line 12—12, Figure 11.

Referring to the accompanying drawings, and more particularly to Figure 1, 1 designates a pair of crushing jaws or elements, which may be of the usual type adapted to provide a gradually decreasing space therebetween for the material to flow therethrough while being acted upon. Each jaw is pivoted at its upper end to a crank or eccentric 2 on a shaft 3 mounted in a frame 4 of any suitable construction; it being understood that there is a bracket at each end of such frame, and that these brackets are suitably connected to form the frame structure, while the shafts are mounted in suitable bearings in that frame. The lower end of each jaw is pivoted upon a second crank or eccentric 5 on a shaft 6 also mounted in suitable bearings in the frame. Shafts 3 are connected by intermeshing gears 7, while shafts 6 are connected by intermeshing gears 8, and the gears 7 and 8 are in turn connected by intermeshing gears 9 on shafts 10 also mounted in bearings in the frame. It will be understood that one or all shafts 3, 6 or 10 may be connected to a suitable source of motive power. Since the shafts are all interconnected by the gears, they will all rotate together; and with a given direction of rotation of shafts 10, as shown in Figure 1, shafts 3 and 6 will rotate in the direction shown by the arrows. During rotation of the shafts, the jaws will be moved collectively, i. e., together, along the flow of the material as they approach and recede, and these movements of the jaws will be in annular paths, one component of each path being along the material flow, while the other components of the path approach and recede relatively.

Where the apparatus is designed for use as a pulverizer for reducing small particles, the angle between the jaw faces is narrow, as illustrated in Figure 1 and also in Figure 2, which illustrates the movements of the jaws during the pulverizing operation. A complete cycle of movement is shown by the positions *a*, *b*, *c* and *d* in Figure 2. From this figure it will be seen that when the jaws are apart they are at their upper limits of their travel; as these jaws approach they also move down in the direction of the flow of the material; as the jaws then recede and have reached the lower limits of their travel their movements are again reversed so that they travel upwardly in a direction opposite the flow of the material therebetween. It will, therefore, be seen that, during the upward movement of the jaws and while they are receding or apart, the relative movement between the material and the jaws will be equal to the flow due to gravity, plus that due to the upward movements of the jaws. Furthermore, during the downward movement of the jaws, any particle caught therebetween will be carried downward at a speed equal to the downward speed of the jaws. It will, therefore, be seen that the flow of the material between the jaws is not solely dependent upon gravity, but is dependent upon the speed of movement of the jaws; accordingly, the flow of gravity during pulverizing is augmented so that the capacity of the machine is increased.

Referring now to Figure 3, which illustrates a

pair of crushing jaws designed for the reduction of large pieces, and in which the angle between the jaw faces is large, it will be seen that the direction of rotation of the shafts 3 and 6 has been reversed. This will modify the action of the jaws during the operation of crushing. The various positions of the jaws during a cycle are indicated at *a*, *b*, *c* and *d*. It will be seen that, when the jaws are at the lower position of their travel, they are again apart; however, as these jaws approach, they travel upwardly instead of downwardly, and, therefore, against the flow of the material, while the downward movement of the jaws takes place when they are apart or receding, so that the jaws will move downwardly with the material. It will, therefore, be seen that, in the operation of crushing, the fall due to gravity is modified in that the travel of a particle between the jaws is lessened rather than augmented. The flow of the material is, therefore, held back, and this is especially true of the larger pieces; thus a given piece dropping between the jaws will be carried back against the stream flow and then released and allowed to drop, while the smaller particles are permitted to drop further; although these also are carried back to some extent. This can be readily seen from the following illustration: Let us say that the travel of the jaws during one revolution is equal to the fall due to gravity; with this condition, the pieces will be thrown back as far as they fall, so that they will make no progress. But let us assume that a piece is reduced in diameter so that the jaws do not touch it when they come together; this piece then continues to fall until it reaches a point where the space is narrow enough to catch it and arrest it in its fall. As this piece is crushed, it will proceed; however, if there are pieces lower down which cannot get through, they will be thrown back until crushed.

It will be seen that, whether the operation be one of pulverizing (Figure 2) or crushing (Figure 3), it is not necessary that the speed of rotation of the shafts or the movement of the jaws be anything definite; for no matter at what speed the jaws are moved, they will have their effect on modifying the fall of the material between the crushing faces, and "packing" of the material will be prevented, whether the operation be that of pulverizing or crushing.

Figure 4 shows another embodiment of this invention, in which similar parts are referred to by similar reference characters, as in Figure 1. The cranks or eccentrics 5 are in this case, however, connected with links 11 jointed to the jaws 1 at 12. The operation will be readily understood, as it is in a general way similar to that illustrated in Figure 1. While the angle of the jaws and the direction of rotation are shown as adapted particularly for pulverizing, it will be seen that, by increasing the jaw angle and reversing the rotation in accordance with Figure 3, the apparatus can be used for crushing or reducing larger pieces. In this embodiment, the throw of the cranks or eccentrics 2 can be varied with reference to the throw of the cranks or eccentrics 5, so that any desired vertical movement of the jaws may be secured.

Figure 5 shows another embodiment of this invention, in which similar parts are again designated by similar reference numerals, as in Figures 1 and 4. The cranks 2 are, however, connected to links 13 pivoted to the jaws at 14, while cranks 20 on shafts 30 are connected to links 15 also pivoted to the jaws at 14. In this particu-

lar embodiment, the vertical movement of the jaws may be varied and increased or decreased without modifying the approaching or receding movements of the jaws. In Figure 5 additional gears 90 may be provided in order to avoid undue increase of the gears 7, 8 and 9. While in Figure 5 the angle of the jaws and the direction of rotation are such as to adapt the apparatus for pulverizing, it will be seen that, by increasing the angle between the jaws and by reversing the direction of rotation, the apparatus may be adapted for crushing or reducing larger pieces.

Figure 6 shows another embodiment of this invention, in which similar parts are designated by similar reference characters, as in Figure 1. Each of the cranks 2 and 5 is journaled in this case in a bearing sleeve 16 of any suitable bearing metal, and this sleeve is mounted in a suitable yielding cushion 17 in turn mounted in a head 18 on the jaw. The cushion 17 may be of any suitable yielding material, such as high compression rubber, which is secured in place by compressing it to secure, say, a one-eighth reduction. There are thus provided yielding connections between the jaws and the operating means, which are adapted to permit these jaws to move relatively those operating means. If, now, the jaws move freely without material therebetween, the inertia of the jaws and the centrifugal forces caused by rotation about the shafts 3 and 6 will, by the yielding of the cushions, cause the jaw faces to move beyond their normal movements if they are not restrained. If the cushions are so arranged that the rubber extends laterally a greater distance beyond the bearing sleeve than vertically, then a given point on the jaw will travel in an ellipse, as distinguished from traveling in a circle. This is illustrated in Figures 7 and 8, where, for instance, the shaft is shown at 3, the crank at 2, the normal travel at *e*, and the travel in the ellipse at *f*. As will, however, be explained, the long axis of the ellipse is not on a horizontal axis, but will deviate in one or the other direction, as indicated at *g* (Figures 7 and 8), dependent upon the rotation of the shaft 3, whether the apparatus is used for pulverizing (Figure 7) or for crushing (Figure 8). This is because there is a lag between the eccentric and the jaw due to inertia or mechanical hysteresis. The advantages of this will now appear.

During the operation of crushing, and assuming that pieces now drop between the jaws, each piece will be struck a hammer blow, due to the fact that the jaw is thrown inwardly, due to inertia and centrifugal force, whereby the jaw will strike the particle and deliver a hammer blow. Part of the inertia will be taken up in the crushing of the particle, and by proper design the inertia can be practically relied upon to secure breakage or compression of the piece so that strain on the bearings will be eliminated to that extent. As the jaws move back, the energy is again accumulated, due to the fact that the outward movement of the jaw is free, and this accumulated energy will again be delivered to the piece as a hammer blow. Upon reference to Figures 7 and 8, in connection with Figure 6, it will be seen that the mechanical hysteresis is even taken advantage of; for during pulverizing, the greatest blow is downward on a small particle, which requires a greater blow, while during crushing the blow is upward, so as to split up a larger particle and tend to deflect it up so as to avoid "packing."

Figures 9, 10, 11 and 12 show a practical em-

bodiment of this invention. The crusher comprises a base 25, which has mounted thereon end frames 26 braced by suitable bolts or cross pieces 27 having reduced ends 28, to provide shoulders, and secured by nuts 29. The jaws 1 have facings 31 of any suitable construction, and these jaws are operated through eccentrics 2 and 5 on shafts 6 connected through gears 7, 8 and 9. The shafts 3 and 6 may be individually driven by motors 32, one for each shaft, through suitable couplings 33, and these motors are held in synchronism by the gearing connecting the shafts. The gears may be housed in a suitable casing 34.

The eccentric straps 35 are connected with a head 36, which is in turn strengthened by cross pieces 37, which provide pivots for links 38 connecting with similar cross pieces 39 on the jaws. The purpose of these links is to prevent upward movement of the jaws relative to the heads 36. Each head 36 has seats 41 for high compression rubber 42 bearing against a seat member 43 on a jaw. In this way each jaw is yieldingly connected with a head 36. It will be understood, of course, that the rubber cushions 42 are inserted while under compression of, say, a reduction of one-eighth in length as previously described. Each shaft 6 has fixed thereto a counter-weight or balance 44, and suitable anti-friction bearings 45 of any suitable or usual construction may be provided; while these bearings are in this case shown as bushings, it will be understood that they may be roller or ball bearings.

It will be seen that the operation of the practical embodiment shown in Figures 9, 10, 11 and 12 is similar to that shown in Figure 6. The vertical movement of the jaw is, however, restrained on account of the links 38, so that the minor axis of the ellipse f (Figure 7) will be equal to the diameter of the crank throw. The major axis of the ellipse will, however, be of the form indicated in Figures 7 and 8, dependent upon the direction of rotation and upon whether the machine is used for pulverizing or crushing, as previously explained.

While there has been illustrated a number of embodiments of this invention, it will be understood that this invention is susceptible of various other embodiments. It will further be understood that, while apparatus is described and shown for the purpose of carrying out the process, the process is not dependent for its operation upon any particular form of structure, but may be carried out by various means and by even elemental operations. It will further be understood that this invention as a process and apparatus is applicable for the reduction of various materials to which it is adapted. It will furthermore be understood that certain features, operations and sub-combinations are of utility and may be employed without reference to other features, operations and sub-combinations; that is contemplated by and is within the scope of the appended claims. It is further obvious that various changes may be made in the details of procedure and construction, within the scope of the appended claims, without departing from the spirit of this invention; it is, therefore, to be understood that this invention is not to be limited to the details described and/or shown.

Having thus described the invention, what is claimed is:

1. An apparatus for comminuting materials, comprising, opposed crushing jaws mounted to provide a space for the flow of material therebetween, means for moving said jaws to rela-

tively approach for crushing and to relatively recede to permit the material flow, and means for moving said jaws collectively in the same direction along the path of the material flow.

2. An apparatus for comminuting materials, comprising, opposed crushing jaws mounted to provide a space for the flow of material therebetween, means for mounting said jaws to move relatively and collectively for crushing, and means for moving said jaws collectively in the same direction along the path of the material flow while they are receding or apart to permit the material flow therebetween.

3. An apparatus for comminuting materials, comprising, opposed crushing jaws mounted to provide a space for the flow of material therebetween, means for mounting said jaws to move relatively and collectively, and means for moving said jaws collectively in the same direction along the path of the material flow while they are approaching or together to crush the material.

4. An apparatus for comminuting materials, comprising, opposed crushing jaws mounted to provide a space for the flow of materials therebetween, means for mounting said jaws to move relatively and collectively, and means for moving said jaws collectively in annular paths whose opposed components are in the same direction.

5. An apparatus for comminuting materials, comprising, crushing jaws mounted to provide opposed relatively inclined faces for the fall of the material therebetween, means for mounting said jaws to move relatively and collectively, and means for moving said elements collectively and upwardly while they are receding or apart to permit the material flow therebetween.

6. An apparatus for comminuting materials, comprising, crushing jaws mounted to provide opposed relatively inclined faces for the fall of the material therebetween, means for mounting said jaws to move relatively and collectively, and means for moving said elements collectively and downwardly while they are approaching or together to crush the material.

7. An apparatus for comminuting materials, comprising, opposed jaws of substantial weight mounted to provide a space for the flow of material therebetween, means for operating said jaws to approach and recede adapted to store momentum therein as they approach, and yielding connections between said jaws and said operating means disposed to yield during approach of said jaws and adapted to permit the jaws to move toward each other after the operating means has begun to recede.

8. An apparatus for comminuting materials, comprising, opposed jaws of substantial weight mounted to provide a space for the flow of material therebetween, means for operating said jaws to approach and recede, and means adapted to store energy therein as the jaws approach and to permit said jaws to move towards each other relatively to said operating means when the jaws approach.

9. An apparatus for comminuting materials, comprising, opposed jaws of substantial weight mounted to provide a space for the flow of material therebetween, means for mounting said jaws to move relatively and collectively, operating means for moving said jaws relatively and collectively, and yielding connections between said operating means and said jaws adapted to store energy as the jaws approach and cause the jaws to lag behind said operating means.

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