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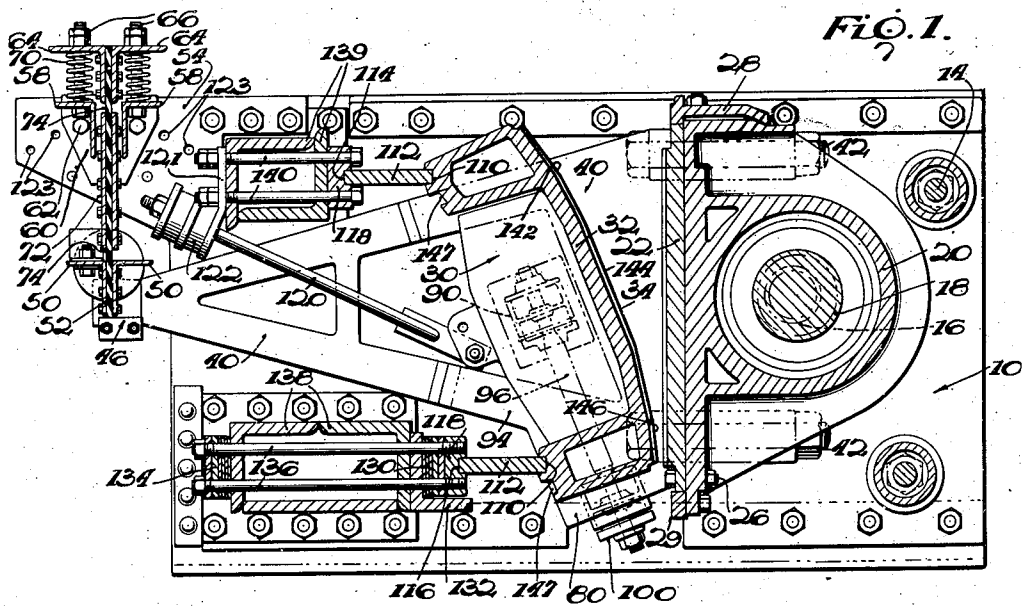
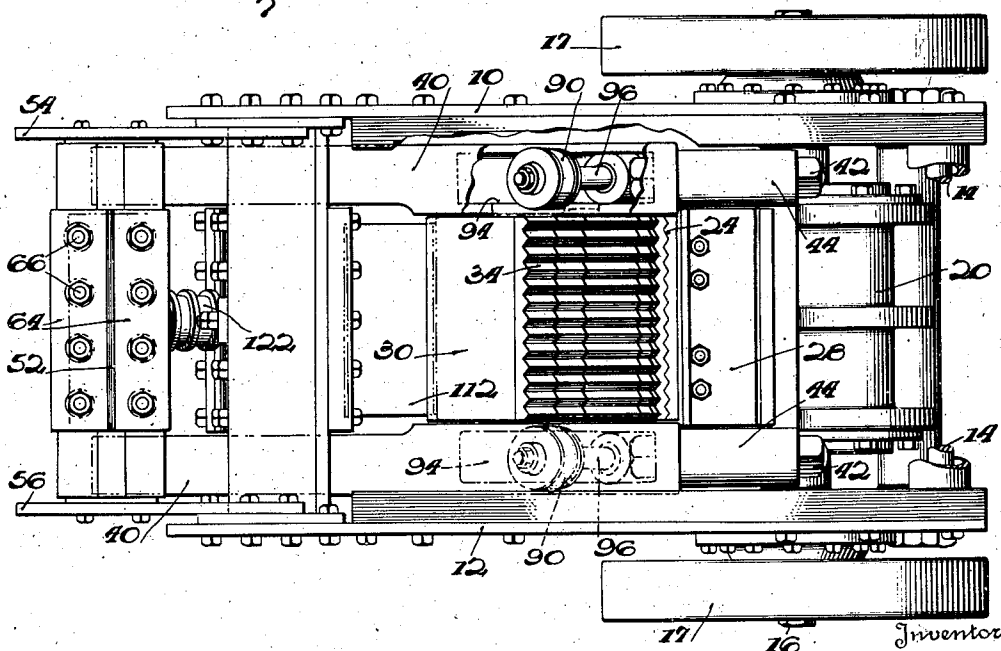


FIG. 2.



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ROCK CRUSHER

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FIG. 3.

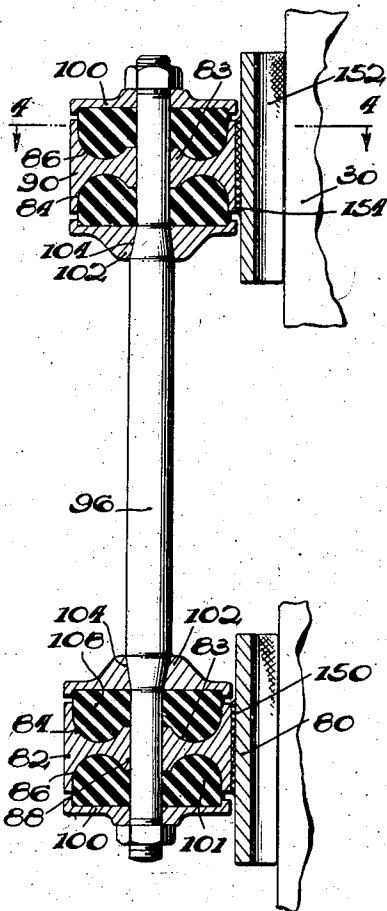


FIG. 4.

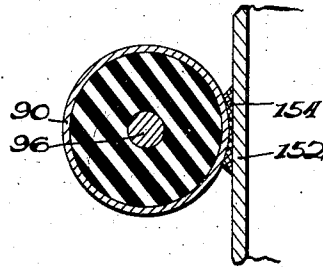


FIG. 6.

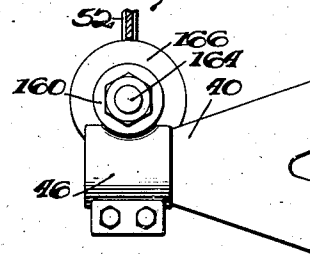
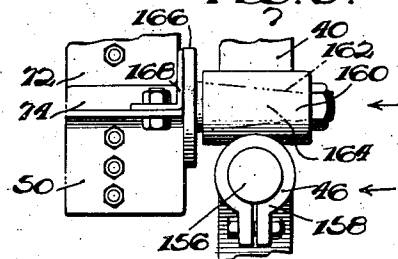


FIG. 5.



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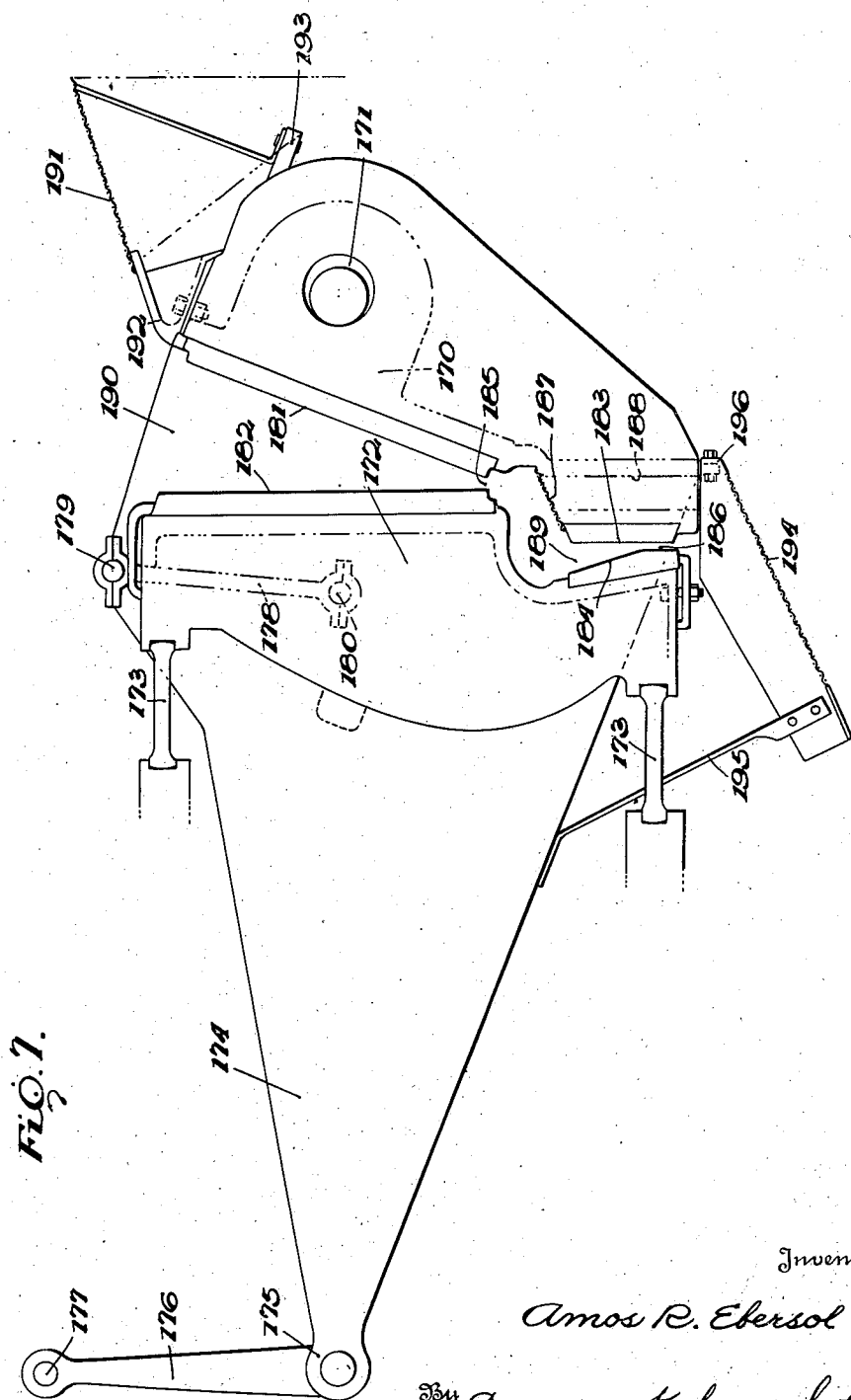
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ROCK CRUSHER

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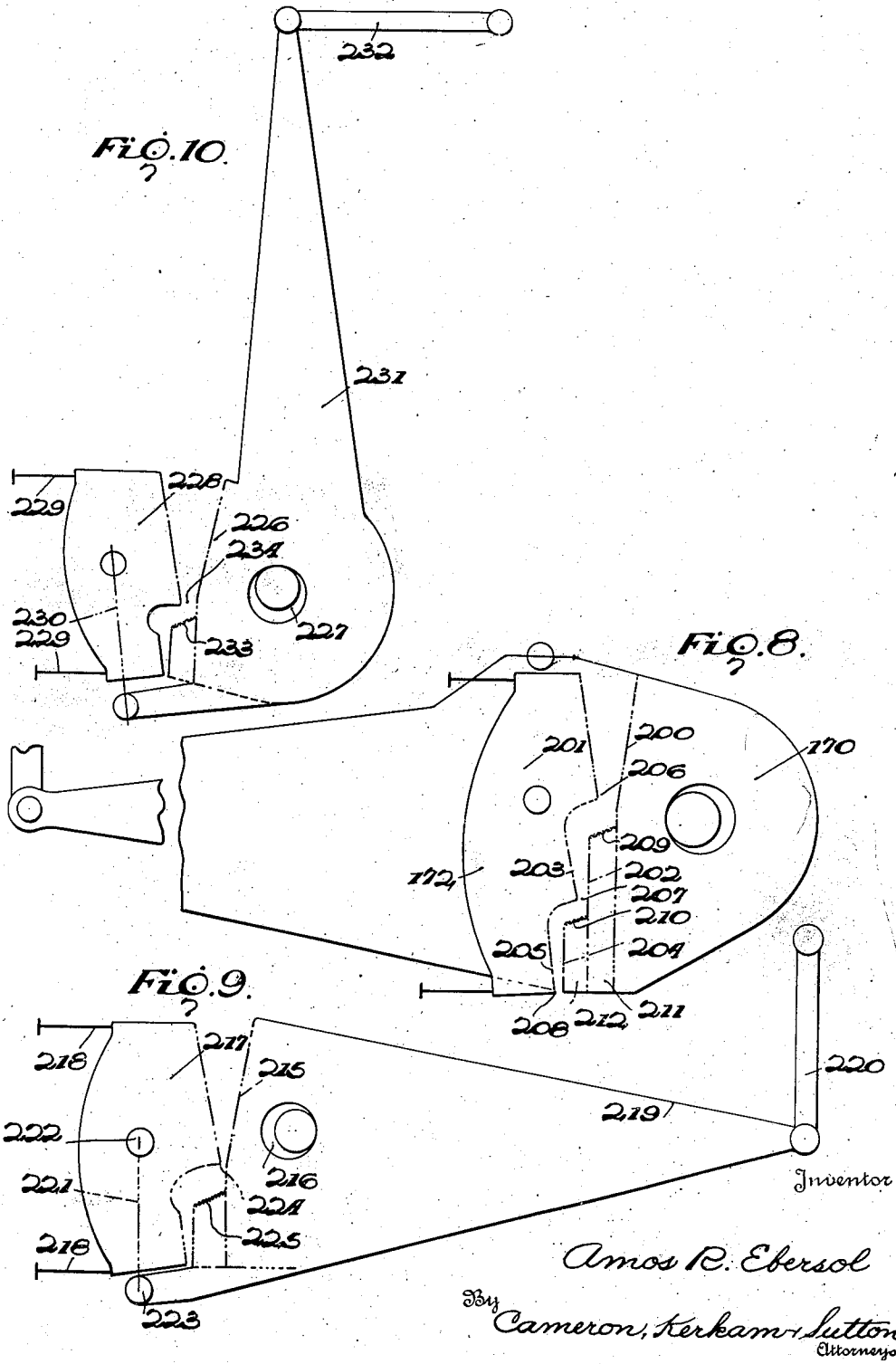
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ROCK CRUSHER

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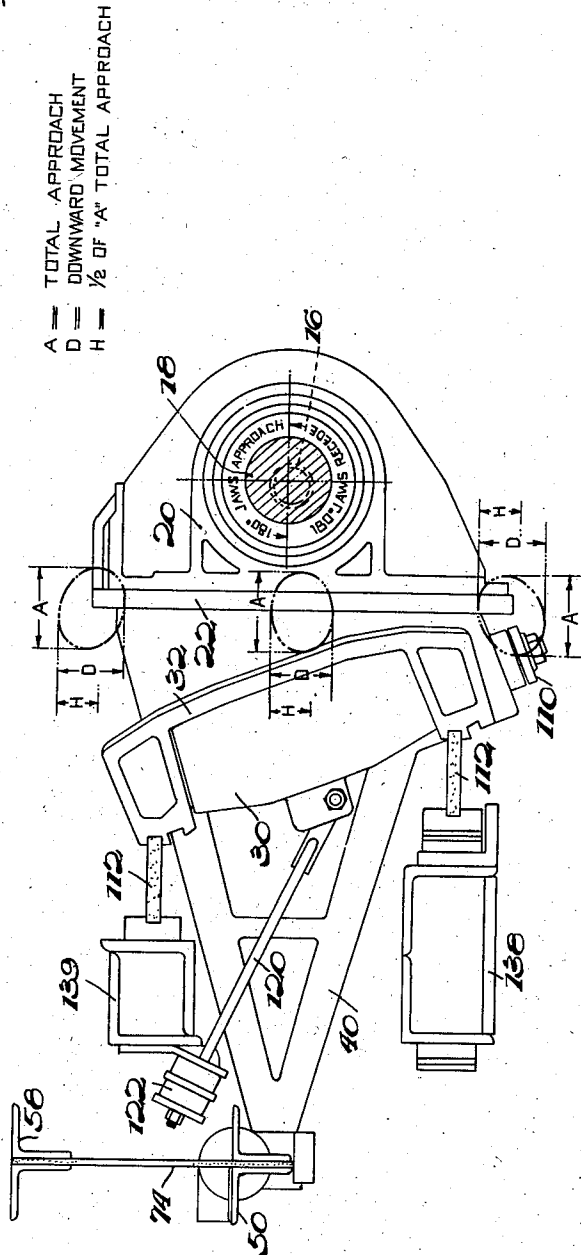
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ROCK CRUSHER

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FIG. 11.



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UNITED STATES PATENT OFFICE

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ROCK CRUSHER

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Application June 16, 1942, Serial No. 447,258

23 Claims. (Cl. 83—53)

This invention relates to apparatus for crushing relatively hard materials such as rock, ore, and the like, and more particularly to what are known as jaw crushers.

It has heretofore been proposed to provide a crusher including a stationary jaw and a movable jaw actuated by an eccentric which cooperates with the movable jaw at a point more or less remote from the throat or exit end of the space between the crusher jaws. In such a construction the frictional opposition to the flow of material between the jaws presented by the face of the stationary jaw materially retards the rate at which the jaws may crush and feed material out through the throat.

It has also been proposed in the patent to Youtsey, No. 1,936,742, granted November 28, 1933, to avoid the friction due to a stationary jaw face by actuating both of the jaw members from eccentrics and synchronizing their movements so that both jaw faces move toward and away from each other and in the direction of material flow during each cycle of operation. As the extent to which the jaws may be speeded up depends on the rate at which the crushed material is discharged from the throat between the jaw faces, a structure of the character just referred to has the disadvantage that, because the movement of the jaws in the direction of material flow cannot exceed one half of the movement of the jaws in their relative approach or recession, the discharge of crushed material from the throat under the action of gravity, supplemented by such motion as can be imparted to the material by the relatively short movement of the jaw faces in the direction of material flow, is not adequate to materially increase the capacity of the crusher. The proposal has also been made to increase the movement of the jaw faces in the direction of material flow by adding a crank movement, but such increase can only be obtained in the device proposed by using additional driving means to swing the jaws on their operating eccentrics as they move through the normal cycle produced by said eccentrics. Such a construction as proposed has the disadvantage of high production, operating and maintenance costs because of its complexity in multiple shafts, eccentrics, bearings, gears, etc.

It has also been proposed, in French Patent No. 731,182, to combine a jaw actuated by an overhead eccentric and having a link mounting adjacent its opposite end with a second jaw movably mounted on parallel links and interconnected with the first named jaw so as to move therewith.

While possessing the advantage that only one eccentric is required to move both jaws, the character of movement introduced by such a construction is undesirable and inefficient, because the operative faces of the jaws have different relative movements at different parts thereof with an intermediate portion where there is little or no relative movement and a consequent tendency to hinder material flow. Furthermore, such a construction causes the throat end of the operative faces of the jaw to move toward each other throughout the period when the jaw faces are moving in the direction opposite to that of material flow. It has also been proposed in the patent to Symons No. 2,302,723 to combine a jaw actuated by an eccentric and having a pivoted link pivoted thereto for controlling the movement thereof under the actuation of the eccentric, with a second movable jaw mounted directly on said link, whereby both crushing faces rock with respect to each other as they relatively approach and recede and thereby the magnitude of movement of the upper end of the eccentrically driven jaw during the crushing strokes is materially less than that of the lower end of said jaw.

It is an object of this invention to provide an improved crusher wherein the jaws are so operated that the rate of flow of the material between and away from the crushing faces of the jaws may be materially increased and therefore the speed of crushing correspondingly increased.

Another object of this invention is to provide an improved crusher wherein the jaws are so operated by the means producing approach and recession of their operative faces that the movement of said faces in the direction of material flow may be materially more than one half of their movement of approach or recession and preferably on at least the same order of magnitude as the movement of said faces toward and away from each other, so that a greater acceleration is imparted to the material while embraced by the jaws and greater impetus given to material on release at the throat between said jaws by the magnitude of the movement of their faces in the direction of material flow and hence the crushed material may be more rapidly and efficiently passed between said jaws and discharged from said jaws.

Another object of this invention is to provide an improved crusher as last characterized wherein the operative faces of the jaws, following the end of the crushing stroke, at which time the jaws are moving at substantially their maximum speed in the direction of discharge, and while the move-

ment of said faces in the direction of material flow is being continued, may be caused to move rapidly away from each other, so that while the crushed material is under the momentum of the movement imparted by the jaws in the direction of material flow, the throat between the operative faces of the jaws becomes freed of the crushed material.

Another object of this invention is to provide an improved crusher wherein one jaw is moved by the other and yet the operative faces of the jaws are moving away from each other at least during the first half of the movement of said faces in the direction opposite to that of material flow.

Another object of this invention is to provide an improved crusher of increased stroke in the direction of material flow as produced by the means causing relative movements of approach and recession wherein the operative faces of the jaws considered as a whole have only one movement of approach and one movement of recession during each cycle of operation so as to overcome the inequality of action and obstruction to material flow implicit in structures wherein the operative faces of the jaws have different portions thereof moving toward each other at different periods in a single cycle of operation.

Another object of this invention is to provide an improved device of the type last characterized wherein the operative faces of said jaws approach smoothly to effect a crushing action during the last half of their movement in the direction opposite to that of material flow and the first half of their movement in the direction of material flow.

Another object of this invention is to provide an improved crusher of the type last characterized wherein the operative faces of said jaws move in the direction of material flow during the last half of their relative approach and the first half of their relative recession.

Another object of this invention is to provide an improved crusher having the jaws so operated that one of said jaws oscillates in or nearly to a straight line generally parallel to the direction of material flow and the other of said jaws has a cyclic movement toward and away from the first named jaw with substantially no rocking movement, so that the angular relationship between the operative faces of said jaws remains substantially constant.

Another object of this invention is to provide an improved crusher as last characterized wherein one of the jaws has a cyclic movement imparted thereto and moves the other jaw in synchronism therewith so as to effect the foregoing objects.

Another object of this invention is to provide an improved crusher of the type characterized wherein one of the jaws has imparted thereto a cyclic motion under the control of a relatively long arm floatingly mounted at a distance from the operative face of said jaw to minimize the rocking movement of said jaw.

Another object of this invention is to provide an improved crusher of the type last characterized wherein the operative faces of two movable jaws retain a substantially constant angular relationship.

Another object of this invention is to provide an improved crusher of the type employing a plurality of synchronously moving jaws with a grading device associated and movable with a cyclically movable jaw to facilitate separation of the fines from the coarser material.

The magnitude of a crushing stroke, involving hard non-compressible material, is determined by the amount of void space in that material. As soon as the stroke has moved far enough to consume the void space the material begins to pack and if the stroke continues the machine will either stall or breakage may result. Since the fines gravitate to the bottom of the passage between the jaw faces, where the jaws are closest together, it is here that packing takes place. Therefore it is the amount of void space in the lower, narrower zone of the crusher which determines the spacing of the jaw faces at the throat. It is another object of this invention to provide means whereby fines created during the crushing in an upper part of the passage between cooperating jaw members can be removed before the material reaches the lower narrower zones, whereby the setting of the jaws at the discharge end of the crusher may be much closer than possible with jaw crushers heretofore proposed.

Another object of this invention is to provide an improved crusher wherein the setting at the discharge end of the crusher, determining how small the material can be crushed, has been so decreased that the ratio of reduction may be so increased in many cases that secondary crushing becomes unnecessary.

Another object of this invention is to provide an improved crusher employing a pair of movable jaws, one of which approaches and recedes with respect to the other to effect crushing and feeding movements of the material flowing between said jaws to carry into effect the foregoing objects, and wherein all movements of both jaws are effected from a single means for driving one of said jaws in a cyclic motion.

Another object of this invention is to provide an improved crusher of the type characterized wherein downward flow of the material by gravity follows rapid acceleration of the material by the movement of the faces of the jaws under the action of the means producing the crushing stroke.

Another object of this invention is to provide an improved crusher of the type last characterized wherein the jaws are so moved that the momentum of the material imparted during the crushing stroke, aided by the force of gravity on said material, as the throat opens, produces a more free and more rapid flow of material from the throat of the jaws than heretofore obtained.

Another object of this invention is to provide an improved crusher of the type characterized wherein rubbing of the material against either jaw face by reason of the relative movement of the other jaw face is minimized so as to reduce wear on said jaw faces and increase the life thereof.

Another object of this invention is to provide an improved crusher of the type characterized wherein one of the jaws moves in a substantially rectilinear path while the other jaw moves bodily toward and away from said first named jaw in a closed curved path which is so controlled as to avoid undesirable relative rocking movements between the operative faces of said jaws and thereby avoid the existence of areas at the operative faces of said jaws at which maximum crushing action does not take place and the desired flow of the material between said jaws is impeded.

Another object of this invention is to provide an improved jaw crusher which can be operated

to crush material at higher speeds than jaw crushers heretofore proposed.

Another object of this invention is to provide an improved jaw crusher as last characterized which is so constructed and arranged that superior balanced conditions are obtained.

Another object of this invention is to provide an improved crusher which is of simple design and relatively low cost of production, operation and maintenance, and yet which is highly efficient in operation.

Other objects of the invention will appear as the description thereof proceeds.

Stated broadly, the present invention provides a crusher having a pair of relatively movable jaws the movement of whose crushing faces in the direction of material flow as produced by the means causing relative movement of approach and recession is materially more than half of the magnitude of their relative movement during the crushing stroke, and preferably on the same order as the crushing stroke, said jaws having means for so coordinating the relative movements thereof that, considering successive quadrants of movements from what is the twelve o'clock position on a clock dial, during the first quadrant of movement said faces approach each other relatively to provide the last half of a crushing stroke while simultaneously moving in the direction of material flow; during the second quadrant of movement said faces continue to move in the direction of material flow but recede relatively from each other so as to discharge the material freely from the throat at the exit end of the space between said faces with the aid of the momentum attained by the material during its movement in said first quadrant; during the third quadrant of movement said faces move in the direction opposite to that of material flow while continuing to move apart relatively; and during the fourth quadrant of movement said faces approach each other relatively smoothly to grip and initiate crushing movement. Owing to the extent of movement of said faces in the direction of material flow, which lasts for substantially a semicycle, the material being crushed has imparted thereto a very considerable momentum which is continued into the last half of said movement, and during which the faces are rapidly receding from each other, so that when gravity starts to act as a discharging force the material already has a high rate of movement in the downward direction. Thereby the crushed material may be discharged at high speed from the throat, the speed of the jaws may be greatly increased, and the capacity of the crusher correspondingly augmented.

While the aforesaid movements of the faces may be effected by driving said jaws separately but synchronously as will hereinafter appear, the preferred embodiment, in the interest of economy and efficiency, employs an eccentric to drive one of said jaws and means operated by said jaw for operating the other of said jaws, preferably oscillating the same in nearly if not quite a straight line, and the movement of the first named jaw is controlled by a relatively long arm floatingly mounted relatively remote from the operative face of its jaw to minimize rocking of said jaw on its eccentric.

The present invention also provides, in association with a cyclically movable jaw, a grading device such as a screen or the like, upon which the material is received either before

entering the crusher or after it is discharged from the throat between said jaws, and whose cyclic movement facilitates separation of the fines from the coarser material. The present invention also provides one or more grading devices interposed between upper and lower pairs of crushing faces so that fines may be removed from the crushed material at intermediate points in the passage of the material through the crusher and therefore, as the lower crushing faces are operating on coarser material with larger voids, the faces may be placed more closely together for a given magnitude of crusher stroke. Thereby the ratio of inlet opening to discharge opening in the crusher may be greatly increased, so that the crusher can take large material for crushing and still assure the desired fineness of the material when discharged.

The invention is capable of receiving a variety of mechanical expressions, some of which are illustrated on the accompanying drawings, but it is to be expressly understood that the drawings are for purposes of illustration only and are not to be construed as a definition of the limits of the invention, reference being had to the appended claims for that purpose.

Referring in detail to the drawings wherein the same reference characters are employed to designate corresponding parts in the several figures,

Fig. 1 is a central vertical longitudinal section through an embodiment of the present invention;

Fig. 2 is a top plan view of the embodiment of Fig. 1, partly in section;

Fig. 3 is an end view of the motion-imparting member which forms a connection between the jaws of the crusher, showing the yieldable connecting means on the end of said member in section;

Fig. 4 is a partial sectional view taken along the line 4-4 of Fig. 3;

Fig. 5 is a partial end view of a means for attaching one of the yokes, which extends forwardly from the first crusher jaw, to a yieldable strap carried by the frame of the machine;

Fig. 6 is a side view of the attaching means shown in Fig. 5 and viewed in the direction of the arrows in Fig. 5;

Fig. 7 is a diagrammatic view of another embodiment of the present invention;

Figs. 8, 9 and 10 are additional diagrammatic views of other embodiments of the present invention; and

Fig. 11 is a diagrammatic view illustrating the relative movement of points on the jaw faces.

Referring to the drawings, particularly to Figs. 1 and 2, the frame of the machine, which may be supported on and from any suitable rigid base, is shown as comprising side plates 10 and 12 rigidly held in spaced relation by any suitable means such as a number of crossed connecting bolts 14. Extending substantially centrally and horizontally through the frame, and adjacent one end thereof, is a drive shaft 16 which is mounted in appropriate bearings carried by the side frames of the machine. This shaft may be driven in any well known manner from any suitable source of power mounted on or connected to the shaft, such as an electric motor or an engine of any appropriate type, the drive being transmitted to the shaft 16 by any suitable means as gearing, belting, etc. One or more flywheels 17 may be provided on the drive

shaft 16, and are here shown as positioned outside of the side plates 10 and 12, performing their usual function.

As shown in Fig. 1, shaft 16 is provided with means for moving one of the jaws of the crusher in a cyclic path, i. e., a path in which any selected point on the jaw moves in a closed curve, said driving means preferably taking the form of an eccentric 18 mounted in a bearing extending longitudinally through the body 20 of the corresponding crusher jaw. The details of such driving means may be those now commonly used in the art for driving the jaws of jaw crushers.

The inner face of the crusher jaw body 20 is preferably flat, and secured thereto as shown is a relatively flat removable jaw face, which may be made of any suitable wear-resisting material such as manganese steel. As is well known in the art, the operating face 22 may be vertically fluted or ribbed or otherwise formed, as shown at 24 in Fig. 2, to facilitate the crushing operation. This plate 22 may be secured to the crusher body 20 in any appropriate manner as by a number of bolts 26 along the upper and lower edges of the plate and body, and also along the side edges thereof if necessary. A top plate 28 may be bolted to the crusher body and have a downwardly extending lower end to bear against the upper end of the crusher plate to give it additional support, and a similar bottom supporting strip or plate 29 may be likewise used in a similar manner.

Mounted on the frame of the machine between the side faces thereof is the other crusher jaw body here designated 30, and while this second crusher jaw body 30 may be independently driven in suitably coordinated relationship with the first referred to jaw body, as by an eccentric or other suitable means for producing the cyclic motion hereinafter described, this crusher jaw body 30, to avoid the use of a separate eccentric or the like, is preferably connected with the jaw body 20 in such a manner, as hereinafter described, that movement is imparted to the jaw body 30 from the drive for the jaw body 20. But while the jaw body 20 moves bodily in a cyclic or closed curved path toward and from the jaw body 30, in movements of relative approach and recession with respect to the jaw body 30 to provide the crushing and recession strokes, said jaw body 20 also having upward and downward movements as hereinafter explained in detail, the jaw body 30 preferably has motion in a nearly if not quite rectilinear path.

Associated with said jaws and their driving means are also means for coordinating or synchronizing the motions of said jaws as hereinafter explained in detail, said means preferably taking the form of a relatively long arm associated with the jaw body 20 and floatingly mounted at its end remote from said jaw, to control the motion of said jaw with respect to its driving means and minimize the extent to which said jaw rocks on its driving means.

The inner face 32 of crusher jaw body 30 is opposed to the inner face 22 of the jaw body 20, and if desired the operating surface thereof may be provided on a removable plate similar to plate 22, or said operating face may be integral with the body 30 of the jaw as is also true of jaw 20. In either event, it is desirable to have the working face of this jaw made of some abrasion-resisting material such as manganese steel, and the inner face 32 of the jaw 30 as shown is fluted vertically to provide longitudinal ridges 34 to facilitate the crushing action.

As shown in Fig. 1, the working face 22 of the jaw 20 is substantially perpendicular to the horizontal, while the working face 32 of the jaw 30 is slightly inclined therefrom, or may be slightly curved, so that the two working faces converge downwardly toward one another to constitute a throat at the lower end of the space between said jaws. While the jaw face 32 is thus somewhat inclined, it may be said that the two jaw faces are substantially vertically disposed in the sense that they provide a path for the flow of material therebetween under the influence of gravity.

Attached to the opposite sides of the jaw 20 are substantially triangular-shaped arms or yokes 40, here shown as extending forwardly from the crushing face 22 thereof on the opposite sides of the jaw 30 and between the side frame members 10 and 12. The inner end or base of each yoke 40 is suitably flanged and connected by a bolt or bolts 42 to the jaw 20, the bolts being shown as passing through cylindrical collars 44, in the form illustrated in Fig. 2, which collars are here shown as formed integrally with the sides of the fixed jaw 20 adjacent the upper and lower ends thereof. The base of the yokes 40 may also be bolted to flanges along each side of the jaw 20 if desired.

As shown in Fig. 1, the top and bottom edges of each yoke 40 converge toward the apex end 46 of the yoke, where the yoke is provided with a floating mounting, by which term as used herein, is meant a mounting which permits relatively free movement in one direction during normal crushing operations but substantially opposes material movement in a direction at right angles to said first named direction except as the movement in question is substantially arcuate. In the form here shown, said floating mounting is provided by a yieldable connection with the frame of the machine, the details of this yieldable connection being shown in Figs. 5 and 6. In general, this yieldable connection is such that while horizontal movement of the forward or apex end of the yoke is permitted, substantial vertical movement thereof is prevented, whereby the crushing face 22 of the jaw 20 will move bodily in a closed curved path toward and from the jaw face 32 while said jaw face 22 is moved upwardly and downwardly as hereinafter explained. Because of the relatively remote disposition of the floating mounting or yieldable connection at the end of the arm formed by the yokes 40 from the jaw face 22 and particularly its discharge end and also from the eccentric which drives the jaw 20, as compared with the distance of the eccentric from the jaw face 22 or more particularly the discharge end of the operative face of jaw 20, undesirable rocking of the crushing face of the jaw 20 is prevented. Consequently, the jaw 20 is so controlled by said floating mounting cooperating with said jaw through said arm that its crushing face 22 maintains the desired substantially constant angular relationship with the opposed jaw face 32 throughout all movements of the jaw 20, without any substantial pivoting action of the yoke such as to cause an undesirable rocking of the face of jaw 20. In other words, owing to this floating control, the magnitude of movement of the upper end of jaw face 22 is substantially the same as that of the lower end of said face, all points on the face 22 having a crushing stroke which is substantially equal to the throw of the eccentric 18.

In the machine illustrated in the drawings, the point of connection of the yoke with the

frame of the machine is spaced from the center of the eccentric a multiple of the distance from the center of the eccentric to the crushing face of the jaw, this distance being shown as on the order of four times the distance from the center of the eccentric to the crushing face of the jaw 20, but this ratio may be varied, the ratio of 4 having been selected as merely exemplary of the order preferred therefor. This relatively remote location from the face of the jaw of the point of connection of the yoke with the frame, as compared with the distance between the center of the eccentric and the jaw face, is important because it insures that the movement of the jaw face in an up and down direction, i. e., at a substantially right angle to the length of the yoke, is nearly equal to the throw of the eccentric, thereby insuring maximum jaw face movement in this direction. While the eccentric has been shown as on the remote side of the jaw from the floating connection, it is apparent that the eccentric may be on the near side of the jaw as hereinafter explained, the ratio of distances preferably being maintained on the same order as referred to, and in this latter relationship, by suitable selection of the ratio, up and down movement of the jaw face may be increased with respect to the magnitude of the eccentric throw so that the movement of the jaw faces in the direction of material flow, as hereinafter explained more fully, may be made larger than the eccentric throw.

Referring again to Fig. 1, each of the ends 46 of the respective yokes 40 is rigidly secured in any suitable manner to two L-shaped cross connecting plates 50, and bolted between said plates in the form shown is a thick vertically disposed strap 52 of yieldable and preferably resilient material, such as a rubber composition or the like, which extends laterally throughout the space between the respective yokes 40. Extending between the end extensions 54 and 56 of the side plates 10 and 12, respectively, are two additional spaced, L-shaped members 58 fixed at their ends, as by welding or bolting, to plates 60, which in turn are secured, as by bolts 62, to the inside faces of the extensions 54 and 56, respectively. The strap 52 extends upwardly between the vertical flanges of the L-shaped members 58, and at the upper edge of the strap it is held between a third set of L-shaped members 64 of length substantially equal to the members 52 and 58. The upper end of the strap 52 is bolted between the vertical flanges of the members 64, and vertically disposed bolts 66 extend between the horizontal flanges of the angle members 58 and 64, there being a plurality of such bolts extending across the machine and between the two said flanges as shown in Fig. 2, and each bolt 66 carries a yielding compression spring 70 interposed between said horizontal flanges. The mid portion of the strap 52 may be strengthened by one or more plates 72 arranged on opposite sides thereof and held together in any suitable way as by bolts extending through the strap, as shown in Fig. 1.

The strap 52 is of such material, dimensions and strength, and it is so arranged, that it substantially resists vertical stretching or compression during normal operation of the machine. However, at zones 74 between the upper and lower ends of the plates 72 and the lower and upper extremities of the angle members 64 and 50, respectively, the strap 52 is not rigidly held, and hence at these points the strap is yieldable to flex a limited extent in the direction of the yokes.

By this arrangement, movement of the jaw 20

resulting from the operation of the eccentric 18 is controlled from a remote point by a floating connection to the fixed frame structure, and this control is such that any vertical movement of the ends 46 of the yokes 40 is substantially resisted and movement of the yokes at this point is enforced to be substantially horizontal. Hence, by this arrangement, and in cooperation with the functioning of the eccentric 18, together with its position adjacent the jaw 20, said jaw and its crushing face 22 move bodily in a closed curved path both toward and away from the jaw 30 and its face 32, and upwardly and downwardly, while the plane of the operating face 22 of the jaw 20 maintains a substantially constant angular relationship to the horizontal throughout all of such movements of the face 22. By reason of the springs 70, however, the jaw 20 may, in an emergency, be forced from its normal path of movement without injury to the machine; that is, assuming a foreign body that cannot be crushed, such as a piece of metal, between the jaws, the working parts of the machine will not be injured because when the foreign body reaches the lower areas of the jaws below the driving shaft the yieldability of the springs 70 permits the jaw 20 to turn about its shaft in a manner not occurring in ordinary operations but sufficient to release the foreign body without injury to the machine.

Referring to Figs. 5 and 6, one manner of securing the apex ends of the yokes 40 to the yieldable strap 52 is illustrated. As shown in Fig. 5, the end of each yoke 40 carries an extending pin 156, and secured around this pin is a removable strap 158 having a longitudinal opening for the pin 156, the strap being integral with a collar 160 having a conical socket 162 extending at right angles to the length of the pin 156. There is a conical bolt 164 secured in the socket 162, and the inner end of said bolt has a flange 166 which may be secured, as by welding, to an angle member 168 attached to the horizontal flange of the angle member 50. The arrangement of parts, shown in Figs. 5 and 6, is duplicated on opposite sides of the machine for each yoke.

As before referred to, the jaw 30 is preferably so connected to the jaw 20 as to have movement imparted to it by said jaw 20. A suitable arrangement is shown in detail in Figs. 3 and 4. First referring to Fig. 1, however, it will be noted that the lower arm of each yoke 40 adjacent its inner end has a downwardly extending plate 80. Suitably secured as by welding or bolting to the inner face of each of these plates is a sleeve 82 having a central web 83 (Fig. 3) forming upper and lower chambers 84 and 86 having curved inner walls. There is a central opening 88 extending through the web 83. Similar sleeves 90 are secured to the opposite outer side walls of the jaw 30 about midway the height thereof.

As shown in Figs. 1 and 2, there are elongated openings 94 through the lower arms of each of the yokes 40 adjacent to the inner ends thereof and on each side of the jaw 30 is positioned a motion imparting rod 96. The lower end of each rod has secured thereto a circular flange 100 which is spaced somewhat from the lower edge of the sleeve 82. In the lower chamber 86 of the sleeve 82, between the web 83 and the inner face of the flange 100, is a yieldable bushing 101, of molded rubber or other suitable material, and the rod 96 extends through the central opening 88 as well as through a central opening in the rubber bushing 101. There is also a second flange 102 fixed against upward movement on the rod 96 by bear-

ing against a tapered portion 104 on the rod 96, and this second flange 102 is slightly spaced from the upper end of the sleeve 82, while a second and similar bushing 108, of molded rubber or other suitable material, is disposed in the chamber 84 between said flange 102 and the web 83 with the rod 96 extending through a central aperture in said bushing. The upper end of the rod 96 is connected to the sides of the second jaw 30 substantially centrally of the height thereof by means which may be identical with those previously described at the lower end of the rod 96, including the webbed sleeve and yieldable bushings.

As indicated in Fig. 3, the lower sleeves 82 may be secured in any suitable manner, as by welding at 150, to the inner faces of the downwardly depending plates 80 carried by the lower arms of the yokes 40. The upper sleeves 90 on the connecting rod 96 may be secured in a similar manner to the opposite outside faces of the jaw 30, but in order to maintain the connecting rods 96 in vertical planes, channel members 152 having side webs of proper width may be interposed between the side walls of the jaws 30 and the shells of the upper sleeves 90. These shells may be welded as at 154 to the connecting webs of the channel members, or otherwise attached thereto, and the side webs of said channel members may be similarly welded to the jaw 30.

By the arrangement just described when the movable jaw 20 moves through its curved path of motion said jaw, by reason of the described connection between the lower arms of the yokes 40 and the sides of the jaw 30, will have imparted thereto a reciprocating motion, by which is meant motion back and forth along the same or approximately the same line, in synchronism with the cyclic motion of the first jaw 20. The downward movement of the jaw 30 will be substantially coincident with the downward movement of the jaw 20, and upward movement of the jaw 30 will be correspondingly coincident with the upward movement of the jaw 20. However, while one particular means for interconnecting said jaws so that they move upwardly and downwardly in unison as referred to has been described with considerable particularity, it is to be expressly understood that any other suitable means for driving the jaw 30 from the jaw 20 may be employed.

The arms of yokes 40 have been shown as extending forwardly from the crushing face 22 of the jaw 20 and in the direction of and beyond the second jaw face, this arrangement having a number of advantages as previously referred to. It is to be understood, however, that more broadly considered the principle of the present invention may be employed in a machine in which the arms carried by the first jaw and which are yieldably connected with the frame as hereinabove described may extend from the first jaw in directions other than that illustrated in the drawings as will be apparent from further embodiments of this invention to be described.

As before referred to, the jaw 30 is preferably so controlled that the movement imparted thereto is one of reciprocation in a nearly if not quite rectilinear path. In the form shown, the rear face of the jaw 30 has extending horizontally across the same, and adjacent the upper and lower ends thereof, spaced parallel grooves 110 and in said grooves are received for pivotal movement the inner ends of upper and lower pivot plates 112, such plates having a length substantially equal to the width of the jaw 30 and being of substantially the same width and parallelly

disposed. The outer edges of the plates 112 are supported for vertical pivotal movement in similar upper and lower grooves 114 and 116 which extend across the inner faces of horizontal supporting blocks 118 rigidly mounted on the frame of the machine. The opposite pivoting edges of each plate 112 are rounded, in the form shown, on an arc whose center is midway along the width of the plates as viewed in Fig. 1. By this arrangement the movement of the jaw 30 is restrained so that any point on the working face 32 of this jaw moves upwardly and downwardly along the same straight line so long as the extent of movement is not such as to bring the point of contact between each end surface of a plate 112 and its cooperating working face off of said arc. However, by providing knife-edged or other suitable surfaces of contact between the opposite ends of the plates 112 and the corresponding faces on the jaw 30 and blocks 118 the movement of the jaw 30 may depart slightly from a precise rectilinear path, the plates 112 constituting a parallel motion linkage whereby the face of the jaw 30 remains always parallel to itself. By varying the length or angularity of said plates even precise parallel motion may be departed from, but the jaw 30 preferably has such a motion that it oscillates along nearly if not exactly a path in which its face is at all times parallel to itself. Thus while the jaw 20 moves in a closed curved path, the movement of the second jaw 30 is substantially that of reciprocation, and this change of movement or dissimilar paths are permitted by the yieldable connection between the jaws as previously described. Hence the jaw 30 does not move bodily toward and away from the jaw 20, but merely oscillates along a substantially straight line path which is roughly parallel to the direction of material flow while the relative approach and recession of the jaws toward and away from each other are effected solely by the cyclic movement of the jaw 20.

In order to hold the jaw 30 against the plates 112 a tie rod 120 is shown as connected to a bracket on the outer face of the jaw 30 and fixed to the frame of the machine in any suitable manner as by a bracket at 121. It is preferable to yieldingly hold the jaw 30 against the plates 112 and for this purpose the tie rod 120 may be spring mounted within a cylinder 122 so that a yielding outward pull is applied to the jaw 30 to hold it against said plates 112 while permitting reciprocating movement of said jaw.

In the form shown, a number of additional bolt holes 123 are provided in the extension plates 54 and 56 whereby the plates 60 carrying the angle members 58 may be adjusted to various positions to change the direction of the restraining influence at the outer ends of the yokes 40. By altering the position of these plates 60, the motion of the jaw 20 may be varied to some extent.

The spacing of the jaw 30 from the jaw 20 may be adjusted by varying the horizontal position of the lower end of jaw 30. For this purpose, the position of the lower plate 112 may be changed toward or from the crushing face 32 by the insertion or removal of shims 130 between the lower block 118 and an angle member 132 secured to the frame and supporting the toggle block 118 and said shims. Additional shims 134 may be provided around the opposite ends of the bolts 136 which extend through the block 118 and hold it rigidly against the angle member 132. These bolts extend through the additional cross frame members 138, in the form shown, and the

position of the block 118 can be varied by changing the shims from their position in the angle member 132 to a position outside the frame angle member 138. The upper block 118 is shown similarly supported by bolts extending through cross frame angle members 139, and while this upper block is not shown as equipped with shims or other equivalent means, if it is necessary to adjust the same such shims may be provided in the manner previously described in connection with the lower block 118. The bolts 140 which secure the upper block 118 may be conveniently used for suspending the spring cylinder 122 for the tie rod 120, as by means of the bracket or strap 121 shown in Fig. 1.

Referring to the operating or working face 32 of jaw 30 it is shown as progressively flared outwardly adjacent its upper end, as at 142, to widen the opening into which the material may be fed. The central portion of this crusher face converges downwardly in a plane 144. At the lower end of plane 144 the operating face may be provided with further progressively beveled areas as shown at 146, until the lower portion of these areas become almost parallel with the face 22 of the jaw 20. However, any other suitable shape of jaw faces may be used.

As shown in Fig. 1, there is an additional pair of plate grooves 147 extending across the rear face of the jaw 30 below the grooves 110. These additional grooves may be used if it becomes necessary to reverse the position of the jaw end for end when the lower portion of the crushing face becomes worn. If this provision for reversibility is thus desired, the upper and lower areas 142 and 146 of the jaw face may be identically beveled or flared so that either may function at the top or bottom of the jaw.

In operation, rock is continuously fed into the opening between the crushing faces and power is applied to the shaft 16 to move the same rapidly, in a counterclockwise direction as viewed in the drawings. The operating or working faces of the jaws form a hopper-like chamber as illustrated, the side walls of the hopper being provided by the vertical plates between the converging arms of the yoke 40 in lateral alignment with the space between the working faces of the jaws. By reason of the location of the eccentric 18 or equivalent drive in the jaw 20 closely adjacent to the crushing face 22 as well as the manner in which the movement of the jaw 20 is controlled by the floating mounting at the free ends of the yokes 40, the crushing face 22 moves bodily in a closed curved path toward and from the crushing face 32 while simultaneously moving upwardly and downwardly. There is substantially no rocking or pivoting action at the face 22, and therefore it is maintained in substantially constant angular relationship with the horizontal during its movement. Simultaneously with the movements of the jaw 20 the jaw 30 is moved upwardly and downwardly in a substantially rectilinear path the upward and downward movements of the operating faces of the two jaws being simultaneous and of substantially the same magnitude by reason of the interconnection between the two jaws, although their paths are dissimilar. Throughout the movement of both jaws their entire faces, considered as a whole, have substantially a semicycle during which the two jaw faces are relatively approaching and substantially a semicycle during which the two jaw faces are relatively receding, the relative move-

ment of approach occupying substantially the last half of their upward movement and first half of their downward movement, while their relative movement of recession occupies substantially the last half of their downward movement and the first half of their upward movement. To express it otherwise, the operating faces are moving as a whole downwardly in the direction of material flow during the last half of their relative approach and first half of their relative recession, and moving in the direction opposite to that of material flow during the last half of their relative recession and first half of their relative approach.

Thus considering the eccentric 18 with its maximum eccentricity at the position of twelve on a clock dial, and remembering that as illustrated the jaw 20 is moving in a counterclockwise direction, during the first quadrant of movement said jaw faces are relatively approaching but moving downwardly; during their second quadrant of movement the faces continue their downward movement but they are relatively receding; during the third quadrant of movement the faces continue their relative recession and start moving upwardly; and during the fourth quadrant of movement the faces complete their upward movement and initiate their relative approach to start the crushing stroke.

The foregoing is diagrammatically illustrated in Fig. 11 wherein like reference characters correlate the parts to corresponding parts in Fig. 1 (but a larger eccentric throw is assumed to proportionately increase the size of the orbit diagrams) and wherein is shown the orbits of movement of the uppermost point, midpoint and lowermost point on the face 22 of jaw 20 during one complete cycle of movement. Inasmuch as the face 32 of jaw 30 is constrained to move upwardly and downwardly with the yokes 40 while the character of its movements is determined by the plates 112, no diagrammatic indication of the movement of points on the face 32 has been attempted because, owing to the substantially straight line movement introduced by the parallel linkage 112, every point on the face 32 is traveling in substantially a straight line. However, as the face 32 is thus moving, in its upward and downward movements, in synchronism with the corresponding movements of face 22, it is to be borne in mind that in the diagram depicted in Fig. 11 the uppermost point, midpoint and lowermost point of the face 32 are substantially in horizontal alignment at all times with the corresponding points on face 22, so that at any instant in the cycle of operation of the cooperating jaws the then location of the uppermost point, midpoint and lowermost point on the face 32 can be determined by projecting horizontal lines from the points then reached by the corresponding points on face 22 in their orbital diagrams, and where such horizontal lines intersect the straight line delineating the movement of face 32 substantially determines the instantaneous location of the uppermost, mid and lowermost points on face 32.

Therefore, the movement of the operating faces of the jaws in the direction of material flow is substantially equal in amount so that relative motion to cause grinding and wearing between the operating faces is substantially avoided. At the same time the motion of the operating faces in the direction of material flow lasts for a substantially semicycle, during the last half of the crushing stroke and the first half

of the recession stroke. Therefore, during the last half of the crushing stroke a substantial momentum is imparted to the material being crushed in a downward direction, and at the close of the crushing stroke, at which time the jaws are moving at substantially their maximum speed in the direction of discharge, said jaws relatively recede rather rapidly so as to free the crushed material at the throat of the space between said jaws whereby said material may flow freely from the throat under the momentum of said downward movement. While this initiation of rapid recession of the jaw faces at their discharge end at the moment of greatest downward speed facilitates the clearing of the throat at the lower end as explained, it is to be further noted that even in the upper zones of the jaw faces the rapid recession of the jaws at this moment of greatest downward acceleration of the jaw faces throws the material in those upper zones a further distance downward than would be accomplished if gravity alone were the only force moving the material on its way through the crusher. Then during the first half of the time when the jaws are moving in the direction opposite to that of material flow, they continue to move apart relatively.

As before explained, the magnitude of the crushing stroke that can be used in crushing hard non-compressible material is determined by the amount of void space in that material, because as soon as the stroke has moved far enough to use up the void spaces, the material begins to pack so that if the stroke continues the machine would either stall or break. The fines gravitate under the crushing action to the lower portion of the space between the operating faces of the jaws, and it is therefore at the throat where the jaws are closest together that packing is most likely to take place. However, the present invention provides a highly efficient means to avoid packing by scattering the material in the finishing zone and moving the crushed material rapidly out of the throat. As compared with structures heretofore proposed employing jaws both of which move in the direction of material flow but by reason of the operating mechanism employed the magnitude of this movement cannot exceed one half of the relative movements of approach and recession, the present invention provides a movement in the direction of material flow which is materially greater than one half of the movement of relative approach or recession, preferably on the order of that movement, without use of additional driving means. Hence the momentum of the material acquired during the last part of the crushing stroke and immediately thereafter is on the order of twice that heretofore obtained so that when the jaws start to recede relatively, at which time gravity begins to act on the crushed material released at the throat, said material already has a relatively high speed on which the acceleration of gravity is superimposed.

Furthermore, as will be apparent, the speed at which pressure jaws can be operated depends upon the rate at which the crushed material may be discharged from the throat. If such material when released is accelerated only by gravity, starting from zero speed, the jaws cannot be brought back toward each other on the next crushing stroke in so short an interval of time that the gravity-fed material has not accelerated sufficiently to get clear of the approaching jaws. The present invention, however, by substantially doubling the distance of movement in the direc-

tion of material flow over what is obtained when the magnitude of motion in the direction of material flow is only half the crushing stroke, doubles the distance (assuming the same magnitude of crushing stroke) during which the material is being rapidly accelerated downwardly by the jaws before the jaws start to open to permit gravity to act, whereby the material is positively and rapidly impelled out of the throat between the jaws. This not only enables the jaws to be speeded up but the increased speed in turn increases the acceleration of the material. Therefore the accumulative effect is a relatively large and disproportionate increase in the capacity of a crusher embodying the present invention.

The present invention also enables the operating surfaces at the throat to be brought more closely together. The fineness of material leaving the crusher is a function of the spacing of the jaw surfaces at the throat, but with structures heretofore proposed the tendency to pack at the throat due to the smaller percentage of voids and therefore the limitation on the magnitude of the stroke, has made impossible as close spacing of the surfaces at the throat as is desirable. The present invention enables the surfaces at the throat to be set at a fraction of what has heretofore been considered feasible, thereby enabling finer as well as more rapid crushing. Additionally, the foregoing can be accomplished without decreasing the size of the inlet opening to the space between the crusher faces, so that the crusher may still operate upon relatively large pieces. In other words, the ratio between the inlet and outlet openings in the passage between the crusher faces can be materially increased by reason of the present invention.

By reason of the connection between the two jaw members the face 32 not only moves upwardly and downwardly in synchronism with the movements of the face 22, but in the embodiment shown, the face 32 reciprocates back and forth in a substantially straight line, which may be exactly a straight line when the members 112 are constructed as heretofore explained, or by use of a parallel linkage motion comparable thereto the face 32 will always remain parallel to itself. However, it is to be expressly understood that the invention is not limited to movement of the face 32 in an exactly straight line or maintenance of exactly parallel relationship, because, by some variation in the length of the elements 112 or in their angularity, some departure from a straight line or parallel linkage movement may be produced while retaining much of the advantage of the present invention. Therefore, the reference herein to oscillatory movement of the jaw face 32 is to be understood as embracing small departures from the movements obtained when a parallel linkage or straight line mechanism is employed as illustrated.

During the last half of the movement of the jaw faces in the direction of material flow they are receding relatively because the eccentric is in the second quadrant above referred to. This movement of relative recession is continued into the third quadrant above referred to, during which the jaw faces are moving in the opposite direction to that of material flow, and hence the material is not being moved contrary to the normal direction of flow under gravity during this period prior to the initiation of the next crushing stroke.

The improved operation above described, and particularly the increased movement of the jaw

faces in the direction of material flow, is obtained by the same mechanism as produces the relative movements of approach and recession, so that the difficulties and complexities incident to the superposition of a crank motion on top of the motion imparted to jaws by a plurality of eccentrics has been avoided. Furthermore, in the preferred embodiment so far described, the entire relative movement of the jaws toward and away from one another is due to the movement of the jaw 20 under the action of its eccentric, and while the jaw 30 moves up and down in synchronism with the jaw 20, it has little or no movement transversely with respect to its operating face, and its entire motion is obtained from the movements of the jaw 20. It will also be noted that in conformity with the present invention the eccentric of the jaw 20 is disposed closely adjacent to the operating face of said jaw where the full movement of the eccentric is available for moving the face of this jaw. At the same time the use of a relatively long arm with a floating suspension at the end thereof relatively remote from said jaw face enables the jaw to be so controlled that it has very little rocking motion on the eccentric—in other words, the jaw is so controlled that its operating face maintains a position which is always substantially parallel to itself. Hence the movement of portions of the operating faces toward each other while other portions of said faces are moving away from each other has been substantially eliminated. At the same time, the yieldable character of the floating mounting enables the jaw 20 to turn on the eccentric in the event that a noncrushable piece of material enters the space between the jaw faces below the eccentric, whereby breakage of the machine is avoided.

The importance of removing fines from the material so as to avoid packing has heretofore been pointed out. For every cubic inch of fines removed there will be an additional cubic inch of void space between the coarser particles available to permit a crushing stroke of greater magnitude than would be possible if the fines remained in the crushed material. Thus the elimination of the fines before the material reaches the throat of the space between the faces of the jaws means that the jaw faces at the discharge end may be set much closer than has heretofore been possible while the magnitude of the crusher stroke may be retained. As this enables finer crushing the ratio of reduction effected by a pair of cooperating jaws may be sufficiently increased so as to eliminate the need for a secondary crushing action.

An important feature of the present invention includes the provision of means for extracting the fines that are created in the upper zones of the space between the jaw faces, so that only the coarser material moves into crushing relationship with the lower zones of said crushing faces. Owing to the presence of larger voids between the particles the operating faces of the jaws may be set much closer together at these lower zones, and therefore finer crushing obtained without decreasing the size of the opening at the inlet end in which the material to be crushed is introduced into the space between the crusher jaws.

Fig. 7 illustrates diagrammatically an embodiment of the present invention which includes means for removing the fines in the course of the traverse of the material between the operating faces of the jaws and which, in the preferred embodiment, takes advantage of the cyclic move-

ment of the eccentrically operated jaw to facilitate the removal of the fines. To facilitate understanding of the invention this embodiment, and succeeding embodiments to be described, have been shown only diagrammatically, but it is to be expressly understood that the construction of the component parts may be the same as more particularly described in conjunction with the embodiments of Figs. 1 and 2, or any other suitable construction of component elements may be employed.

Referring in detail to Fig. 7, jaw 170 is driven from an eccentric 171 analogously as the jaw 20 of Figs. 1 and 2, while the second jaw 172 is constrained to move in a substantially straight line by means of parallel motion links 173 which correspond with the plates 112 of Figs. 1 and 2. Jaw 170 is mounted on an elongated arm or yoke 174 which at its free end 175 is shown as provided with a floating mounting here diagrammatically indicated as a link 176 pivoted on the frame at 177. In this embodiment the jaw 172 is moved up and down synchronously with the jaw 170 by links 178 pivoted to the arm or yoke 174 at 179 and to the jaw 172 at 180, like links 178 being employed at opposite sides of the machine.

As here illustrated the operating faces of the jaws 170 and 172 are divided into two portions 181, 182 and 183, 184, the jaw faces 181 and 183 being on the jaw 170 and the jaw faces 182, 184 being on the jaw 172. As apparent from the drawings, each of the spaces between the pairs of cooperating faces 181, 182 and 183, 184 are inclined toward each other to produce throats at 185 and 186. Mounted on the jaw 170 below, but in alignment with, the throat 185 is a grader device in the form of a screen 187 adapted to receive the discharge from the throat 185. As the screen 187 is mounted on the jaw 170, it will partake of the same cyclic movement as heretofore described as possessed by said jaw 170. The fines which are removed from the crushed material by means of the screen 187 may flow from the crusher through passage 188 while the coarser material is delivered from the screen 187 to the inlet 189 to the space between the second pair of cooperating faces 183, 184.

Thus at an intermediate point in the traverse of the material through the crusher the crushed material is delivered from the throat 185 to the grader screen 187. As the faces 181, 182 and the faces 183, 184 and the grader device 187 are mounted on jaws having movement as heretofore described in detail with respect to the movement of Figs. 1 and 2, the characteristic operation above explained applies equally to this embodiment. During the first and second quadrants of movement above referred to, the jaw faces 181 and 182 are moving downwardly in synchronism to impart momentum to the material being crushed, and then during the second part of this movement in the direction of material flow the faces 181, 182 are moving rather rapidly away from each other to free the material at the throat 185 to the action of gravity superimposed upon the momentum already imparted to the material. Hence the crushed material is delivered at relatively high speed from the throat 185 and received by the grader screen 187. As this screen is also in motion, partaking of the same cyclic motion as the jaw 170, the fines are quickly cleared through the passage 188, while the coarser material flows into the inlet 189 of the space between the faces 183, 184 where this material is

subjected to a further crushing action. As the characteristic voids between the larger particles have been largely cleared of the fines, surfaces 183 and 184 may be set more closely together at the throat 186 and while still using the same magnitude of crushing stroke a finer crushing is obtained. The crushed material is then again delivered from the throat 186 at high speed in conformity with the principles above discussed. Hence finer crushing can be obtained while the ratio between the area at the throat 186 and the inlet 190 may be made several times larger than was heretofore considered feasible.

The embodiment of Fig. 7 also shows as within the broader aspects of the present invention the use of additional grader elements for separating the fines from the coarser material, to take advantage of the cyclic movement of the eccentrically driven jaw in order to facilitate grading of the material, and which may be used with any of the other embodiments described. As here illustrated a screen 191 is mounted in any suitable way as by brackets 192 and 193 so that fines may be discharged from the material being delivered to the inlet 190, and another grader device 194 is shown as suitably mounted, as by brackets 195 and 196, for separating the fines from the coarser material delivered from the throat 186, as may be desirable if said coarser material is to be subjected to a further crushing action.

The embodiment of Fig. 8 illustrates the use of a plurality of grader devices operating between successive pairs of crushing faces. As here shown, the faces of the jaws 170 and 172 are provided with three pairs of crushing faces 200, 201 and 202, 203 and 204, 205 which define the spaces leading to throats respectively indicated at 206, 207 and 208. Below and aligned with the throats 206 and 207 are grader screens 209 and 210 for separating the fines and delivering the coarser material to the inlet to the space between the succeeding pair of jaw faces. The fines so separated are withdrawn through passages 211 and 212. While only three sets of pairs of cooperating jaw faces and two sets of intermediate grader devices have been illustrated in this embodiment, it is apparent that the number may be increased to any desired extent in accordance with the crushing action desired, and for some purpose a fewer number of grader devices than pairs of crushing faces may be used without departing from the broader aspects of the present invention.

Figs. 9 and 10 illustrate diagrammatically yet other embodiments of the present invention to show both the incorporation of the aforesaid grading means in crushers and also to illustrate other features of the invention as previously referred to.

In the embodiment of Figs. 1 and 2 the relatively long arms or yokes 40 are shown as extending on the opposite side of the jaw face 22 from the body 20. This is not essential, as the arms or yokes may extend on the opposite side of the eccentric from the jaw face as shown in Fig. 9, wherein the jaw 215 operated by an eccentric 216 cooperates with a jaw 217 restrained to substantially rectilinear movement by parallel motion links 218. Jaw 215 has relatively long arms or yokes 219 provided with floating mountings at their free ends as by links 220. Jaw 217 is moved from jaw 215 as by one or more links 221 pivoted to jaw 217 at 222 and to an extension on the jaw 215 at 223. In this embodiment the

operating faces of the jaws are shown as subdivided into two pairs of jaw faces separated by a throat at 224 in alignment with which is a grading device 225 as heretofore explained.

In all of the embodiments so far described the long arms or yokes have been shown as extending from the eccentrically operated jaw in a substantially horizontal direction, but the same principles apply if the long arms or yokes extend in a substantially vertical direction or at any intermediate angle. This is illustrated in the embodiment of Fig. 10 wherein the jaw 226 operated by eccentric 227 cooperates with jaw 228 restrained to substantially rectilinear movement by parallel motion links 229 and operated from the jaw 226 as by links 230. In this embodiment the long arms or yokes 231 extend substantially vertically to floating mountings again illustrated as in the form of links 232 pivoted to the frame of the machine. As in the least embodiment described the jaw faces are shown as subdivided into two pairs of cooperating faces and a grader device 233 is positioned to separate the fines delivered by the throat 234.

In all of the embodiments so far described the oscillatory jaw, i. e., the jaw that moves in or nearly to a straight line in the direction of material flow, has been shown as moved from the eccentrically driven jaw, and this is the preferred practice in the interest of economy of initial cost and operating and maintenance expense, because it eliminates the need for separate driving means for the two jaw members together with intermediate gearing for synchronizing their respective movements. However, this is not essential to the broader aspects of the present invention as will be apparent to those skilled in the art.

In each of the embodiments it will be observed that the distance from the eccentric to the discharge end of the operative or crushing face of the eccentrically driven jaw is materially less than the distance from said eccentric to the floating mounting of said eccentrically driven jaw. While the relatively long arm or yoke 40 associated with the eccentrically driven jaw of Figs. 1 and 2 has been shown as having a certain ratio in length to the distance of the jaw face from its eccentric it is to be expressly understood that the invention is not limited to such a ratio as said arm is desirably made as long as permitted by an acceptable size of installation and in practice the arm 40 of Figs. 1 and 2 would preferably be made longer, as has been illustrated in Fig. 7 as well as other figures.

It will therefore be perceived that by reason of the character of the driving and controlling means which coordinate the movements of the jaws of a crusher as here provided each and all of the several objects of the present invention have been accomplished by reason of the novel character of the motions imparted to the operating faces of the jaws as hereinabove explained in detail. By reason of the character of said motions the material may be more rapidly and effectively crushed and discharged from the cooperating pairs of crusher faces, and the capacity of the crusher can be greatly increased by driving it at a much higher speed. These advantageous results have been further increased by the important feature of the present invention where by utilizing the movement of a movable jaw the fines may be separated from the material being crushed, particularly between upper and lower zones or succeeding portions of the operating faces. Furthermore, the foregoing advantages

are obtained by utilizing the same means as drives the crusher members in obtaining the improved character of relative motion without involving the complications and disadvantages implicit in superimposing additional motions on the motions obtained from the driving eccentric or eccentrics. While as above explained the invention may be embodied in constructions using separate driving means for the two jaw members, the present invention provides the advantage of enabling the desired motions to be attained through use of a single driving means for one of the jaws and operating the other jaw therefrom. At the same time the foregoing advantages have been obtained by the use of a construction which is rugged, simple, highly efficient in operation, and possessed of relatively low initial, operating and maintenance costs.

While the embodiments of the invention illustrated on the drawings have been described with considerable particularity, it is to be expressly understood that the invention is not restricted thereto, as the same is capable of receiving a variety of mechanical expressions that will now be apparent to those skilled in the art, while changes may be made in the details of construction, arrangement and proportion of parts, and certain features used without other features, without departing from the spirit of this invention. It is to be expressly understood that while in the embodiments of Figs. 1 and 2 one form of cooperating jaw members, means for moving one jaw from the other, and means for controlling the jaw by a relatively long arm floatingly mounted at its free end, have been illustrated and described in detail the invention is not restricted thereto as any suitable jaw members, any suitable driving means therefor, any suitable means for driving one jaw from the other, and any suitable means for controlling the movement of a jaw in conformity with the principles of this invention may be employed without departing from the spirit thereof. Reference is therefore to be had to the appended claims for a definition of said invention.

This application is a continuation in part of my application Serial No. 375,985, filed January 25, 1941, and entitled Rock crusher.

What is claimed is:

1. In a crusher, a pair of cooperating jaws having opposed crushing faces, a power shaft for one of said jaws, eccentric means on said shaft for bodily moving said one of said jaws in a path of movement downwardly and upwardly and toward and from the other of said jaws, said one of said jaws having an arm thereon projecting from said jaw and extending therefrom substantially in the direction of movement thereof from and toward the other of said jaws, and means for supporting said arm as a point sufficiently remote from said eccentric means so that resistance during normal operation to upward and downward movement of said arm at said point will prevent substantial rocking movement of the crushing face of said jaw, said supporting means permitting full movement of said arm with said one of said jaws in its movement from and toward the other of said jaws, said supporting means being arranged to yield in a direction which permits rocking of said eccentrically driven jaw about the eccentric when non-crushable material is encountered by the jaws.

2. In a crusher, a frame, first and second cooperating jaws carried by said frame with opposed crushing faces, means for driving said jaws

comprising a power shaft and eccentric, said eccentric bodily moving the crushing face of one of said jaws in a closed curved path toward and from said second jaw, said eccentric moving said face downwardly during its motion toward and from said second jaw and upwardly during its motion from and toward said second jaw, an arm extending from said first jaw substantially in the direction of movement thereof toward and from the other jaw, means for movably supporting said arm at a point sufficiently remote from said eccentric so that resistance to movement at right angles to the length of said arm at said point prevents substantial rocking movement of the crushing face of said first jaw, and means operated from said eccentric and connected with said second jaw for imparting upward and downward movements thereto in synchronism with the movements of said first jaw, said jaws moving upwardly and downwardly together.

3. In a crusher, a frame, first and second cooperating jaws supported by said frame with opposed crushing faces, means for driving said jaws comprising a power shaft and an eccentric carried by said frame and bearing in said first jaw immediately behind the crushing face thereof, said eccentric bodily moving the crushing face of said jaw in a closed curved path toward and from said second jaw, said eccentric moving said face downwardly during its motion toward and from said second jaw and upwardly during its motion from and toward said second jaw, an arm extending forwardly from the face of said first jaw and beyond said second jaw, means operatively connected between said arm and said second jaw for imparting movement to the latter in synchronism with the movement of said first jaw, and means for movably supporting said arm beyond said second jaw.

4. In a crusher, a frame, first and second cooperating jaws supported by said frame with opposed vertically disposed crushing faces converging downwardly with respect to one another, means for bodily moving the crushing face of said first jaw in a closed curved path toward and from said second jaw, means for controlling such movement to maintain the plane of the crushing face of said first jaw at a substantially constant angle to the horizontal, said means moving said face downwardly during its motion toward and from said second jaw and upwardly during its motion from and toward said second jaw, means operatively connected with and interposed between said jaws for imparting the motion of said first jaw to said second jaw, and means between said second named jaw and said frame for enforcing reciprocating movement of said second jaw, said jaws moving upwardly and downwardly together.

5. In a crusher, a pair of jaws having opposed crushing faces, one of said jaws having a bearing behind its crushing face, a rotary eccentric cooperating with said bearing to move said first jaw downwardly and upwardly and toward and from the other jaw, an arm on said one of said jaws extending past said other of said jaws, means for movably supporting the free end of said arm so as to accommodate movements of said first jaw, means backing said other jaw and guiding the same for reciprocation downwardly and upwardly, and connecting means between said eccentric and said other jaw whereby the latter is moved downwardly and upwardly with said first jaw.

6. In a crusher, first and second jaws having opposed crushing faces defining a downward path therebetween for the passage of material through

the crusher, rotary eccentric means arranged to move the first jaw, means cooperative with the eccentric means to control the motion of the first jaw, said cooperative means comprising an arm projecting horizontally from the first jaw past the second jaw, and means supporting the outer end of the arm whereby upon each rotation of the eccentric means said first jaw is moved as a whole through a crushing stroke and a receding stroke relative to the second jaw, said first jaw in the crushing stroke moving first inwardly toward the second jaw and upwardly and then downwardly while continuing inwardly, and in the receding stroke moving first outwardly relative to the second jaw and downwardly and then upwardly while continuing outwardly, means guiding the second jaw for reciprocation along the path of material flow, and means connecting the jaws so that movement of the first along the path of flow is imparted from the first to the second.

7. In a crusher, first and second jaws having opposed crushing faces defining a downward path therebetween for the passage of material through the crusher, rotary eccentric means arranged to move the first jaw disposed behind and between the upper and lower ends of the latter's face, means cooperative with the eccentric means to control the motion of the first jaw, said cooperative means comprising an arm projecting horizontally from the first jaw past the second jaw, and yieldable means supporting the outer end of the arm whereby upon each rotation of the eccentric means said first jaw is moved as a whole through a crushing stroke and a receding stroke relative to the second jaw, said supporting means being spaced from said eccentric means a distance which is a multiple of the distance between said eccentric means and the crushing face of said first jaw, said first jaw in the crushing stroke moving first inwardly toward the second jaw and upwardly and then downwardly while continuing inwardly, and in the receding stroke moving first outwardly relative to the second jaw and downwardly and then upwardly while continuing outwardly, means guiding the second jaw for reciprocation along the path of material flow, and means connecting the jaws so that movement of the first along the path of flow is imparted from the first to the second in like direction.

8. In a crusher, opposed crushing jaws positioned to provide a path for the flow of material therebetween, means adjacent one of said jaws for moving said jaw in a closed cycle to provide crushing and recession strokes of said jaw, means for controlling the movement of said jaw from a point remote from the crushing face of said jaw, means for oscillating the other of said jaws from said first named means, said two last means cooperating to maintain a substantially constant angular relationship between the crushing faces of said jaws, the faces of said jaws being subdivided into a plurality of pairs of cooperating jaw sections, and grading means interposed between successive pairs of jaw sections and entirely carried by one of said jaws.

9. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, means for driving said first jaw to move the crushing face thereof in a closed curved path, control means for said first jaw having mounting means cooperating therewith at a location remote from the crushing face of said first jaw and coacting with said driving

means to retain the crushing face of said first jaw at a substantially constant predetermined angular relationship to the horizontal, and means for reciprocating said second jaw in the general direction of material flow.

10. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, means for driving said first jaw to move the crushing face thereof in a closed curved path, control means for said first jaw having mounting means cooperating therewith at a location remote from the crushing face of said first jaw to maintain the crushing face of said first jaw substantially parallel to itself at all times, and means driven from said driving means for reciprocating said second jaw.

11. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, means for driving said first jaw to move the crushing face thereof in a closed curved path, a control member for said first jaw having mounting means cooperating therewith to restrain movement of said member adjacent said mounting means during normal operation to a movement approximately normal to the crushing face of said first jaw, means movably mounting said second jaw directly on said frame to transmit the stress on said jaw directly to said frame, and means operatively connected to said first jaw for reciprocating said second jaw.

12. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, means for driving said first jaw to move the crushing face thereof in a closed curved path, an arm projecting from said first jaw, mounting means cooperating with said arm at a location remote from the crushing face of said first jaw and coacting with said driving means to maintain the crushing face of said first jaw substantially parallel to itself throughout its path of movement, and means for reciprocating said second jaw with its crushing face maintained at a substantially constant angular relationship to the crushing face of said first jaw.

13. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, means for driving said first jaw to move the crushing face thereof in a closed curved path, control means for said first jaw including means projecting therefrom to a point remote from the crushing face of said first jaw, mounting means cooperating with said last named means at said remote point and coacting with said driving means to maintain the crushing face of said first jaw substantially parallel to itself throughout its movement, means mounting said second jaw for reciprocation, and means operatively connected to said first jaw for reciprocating said second jaw.

14. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, means for driving said first jaw to move the crushing face thereof in a closed curved path, an arm projecting from said first jaw on the opposite side thereof from

said driving means and in a direction approximately at right angles to the path of material flow, mounting means cooperating with said arm at a location more remote from the crushing face of said first jaw than is said eccentric means and coacting with said driving means to maintain the crushing face of said first jaw substantially parallel to itself at all times, said second jaw being disposed between said first jaw and said mounting means, means mounting said second jaw on said frame for reciprocation, and means driven from said driving means for reciprocating said second jaw.

15. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, means for driving said first jaw to move the crushing face thereof in a closed curved path, control means projecting from said first jaw, mounting means cooperating with said control means at a location remote from the crushing face of said first jaw and coacting with said driving means to maintain the crushing face of said first jaw at a substantially constant angle to the horizontal, means for reciprocating said second jaw, and means whereby one of said jaws may yield when non-crushable material is engaged between said jaws.

16. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, means for driving said first jaw to move the crushing face thereof in a closed curved path, control means projecting from said first jaw, mounting means cooperating with said control means at a location remote from the crushing face of said first jaw and coacting with said driving means to maintain the crushing face of said first jaw substantially parallel to itself at all times, means for reciprocating said second jaw, and a grading means entirely supported on said first jaw to partake of the full movement thereof and positioned in the path of material flow passing between the faces of said jaws.

17. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, means for driving said first jaw to move the crushing face thereof in a closed curved path, control means projecting from said first jaw, mounting means cooperating with said control means at a location remote from the crushing face of said first jaw and coacting with said driving means to prevent substantial rocking of said first jaw, means for reciprocating said second jaw, the crushing faces of said jaws being subdivided into at least two pairs of cooperating crushing sections, and grading means entirely supported on said first jaw and disposed between upper and lower sections of said faces, said grading means delivering the coarser material to the space between a pair of cooperating face sections below said grading means.

18. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, eccentric means for driving said first jaw to move the crushing face thereof in a closed curved path, an arm projecting

from said first jaw, a floating mounting for said arm at a point more remote from the discharge end of the crushing face of said first jaw than is said eccentric means for restraining movement of the mounted end of said arm to approximately a straight line, the floating mounting for said arm being also remote from said second jaw, and means driven from said eccentric means for oscillating said second jaw.

19. In a crusher, opposed crushing jaws positioned to provide a path for the flow of material therebetween, eccentric means for moving one of said jaws in a closed curved path, means for moving the other of said jaws, said last named means receiving its motion only from said eccentric means, and a floating control for the movement of said first named jaw cooperating therewith at a point more remote from the discharge end of the crushing face of said jaw than is said eccentric means from said discharge end, said second named jaw being supported separately from said floating control and said jaw-moving means coordinating the movements of said jaws to effect relative approach and recession of said jaws and simultaneous movement of both jaws in the direction of material flow during the last part of their relative approach and the first part of their relative recession.

20. In a crusher, opposed crushing jaws positioned to provide a path for the flow of material therebetween, eccentric means adjacent one of said jaws for moving the same in a cycle to provide crushing and recession strokes, means associated with said jaw for controlling said movement and including an arm floatingly mounted at a point remote from said jaw, means separate from said controlling means for movably supporting the other of said jaws, and means driven from said eccentric means for oscillating said other of said jaws in the direction of material flow, said jaw moving and controlling means cooperating with said jaws to move both jaws in the direction of material flow during the last part of the crushing stroke and the first part of the recession stroke.

21. In a crusher, a frame, first and second cooperating jaws supported by said frame with opposed crushing faces positioned to provide a path for the flow of material therebetween, a power shaft carried by said frame, eccentric means on said shaft rearwardly of the crushing face of said first jaw and between the upper and lower extremities of said face, said eccentric means serving to move the crushing face of said jaw in a closed curved path downwardly toward and from an upwardly from and toward said second jaw, an arm extending from said first jaw, means for movably supporting a portion of said arm from a rigid member to control the motion of said first named jaw, said supporting means cooperating with said arm at a point so located with respect to said eccentric means that a straight line connecting the two crosses the path of material flow, and means for moving said second jaw in synchronism with said first jaw.

22. In a crusher, opposed crushing jaws positioned to provide a path for the flow of material therebetween, means adjacent one of said jaws for moving said jaw in a closed cycle to provide crushing and recession strokes of said jaw, means for controlling the movement of said jaw to maintain approximately equal the strokes of the upper and lower extremities of the crushing face of said jaw in the crushing direction,

means operatively connected to said first named jaw for oscillating the other of said jaws, and grading means carried by said first named jaw in said path of material flow and moved by said first named jaw through a closed orbital path of the same character as the movement of the contiguous portion of the face of said jaw.

23. In a crusher, in combination with a supporting frame, cooperating first and second crusher jaws having opposed crushing faces positioned to provide a path for the flow of material therebetween, means for driving said first jaw to move the crushing face thereof in a closed curved path, control means for said first

5 jaw having mounting means cooperating therewith, said control means coacting with said driving means to enforce the movement in the crushing direction of all points on the crushing face of said first jaw by an amount approximately equal to the movement of said driving means in the same direction, said mounting means cooperating with said control means at a point so located with respect to said driving means that a straight line intersecting the two also intersects said second jaw, and means for reciprocating said second jaw.