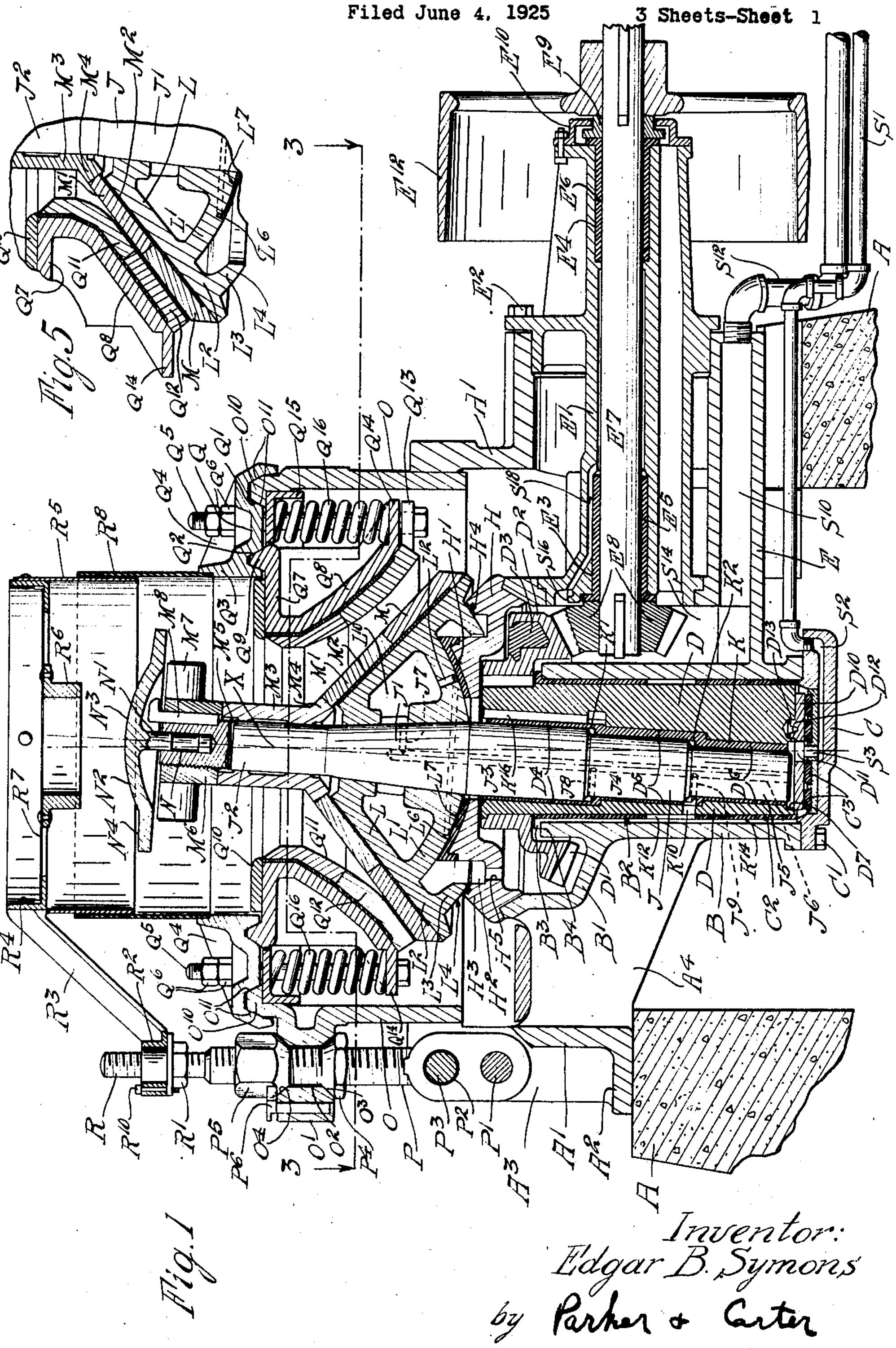
July 13, 1926. 1,592,313

E. B. SYMONS

GYRATORY CONE CRUSHER

Filed June 4, 1925 3 Sheets-Sheet 1



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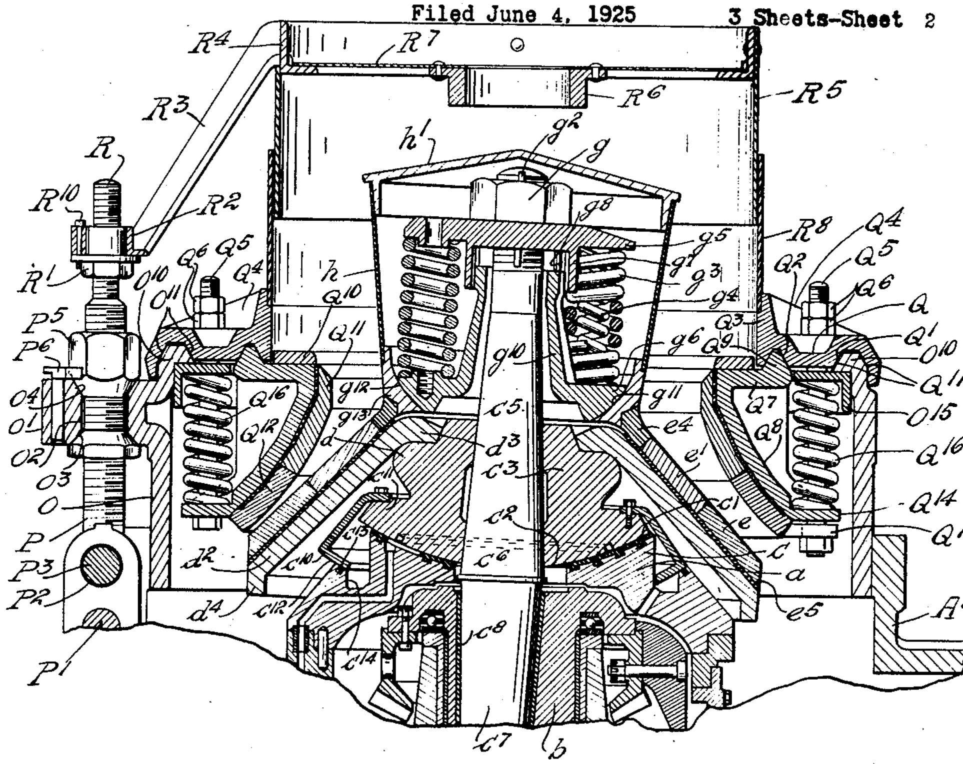

Fig. 4

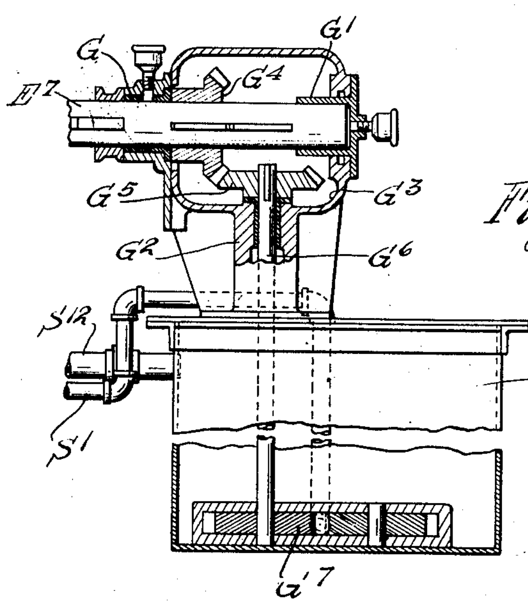

Fig. 2

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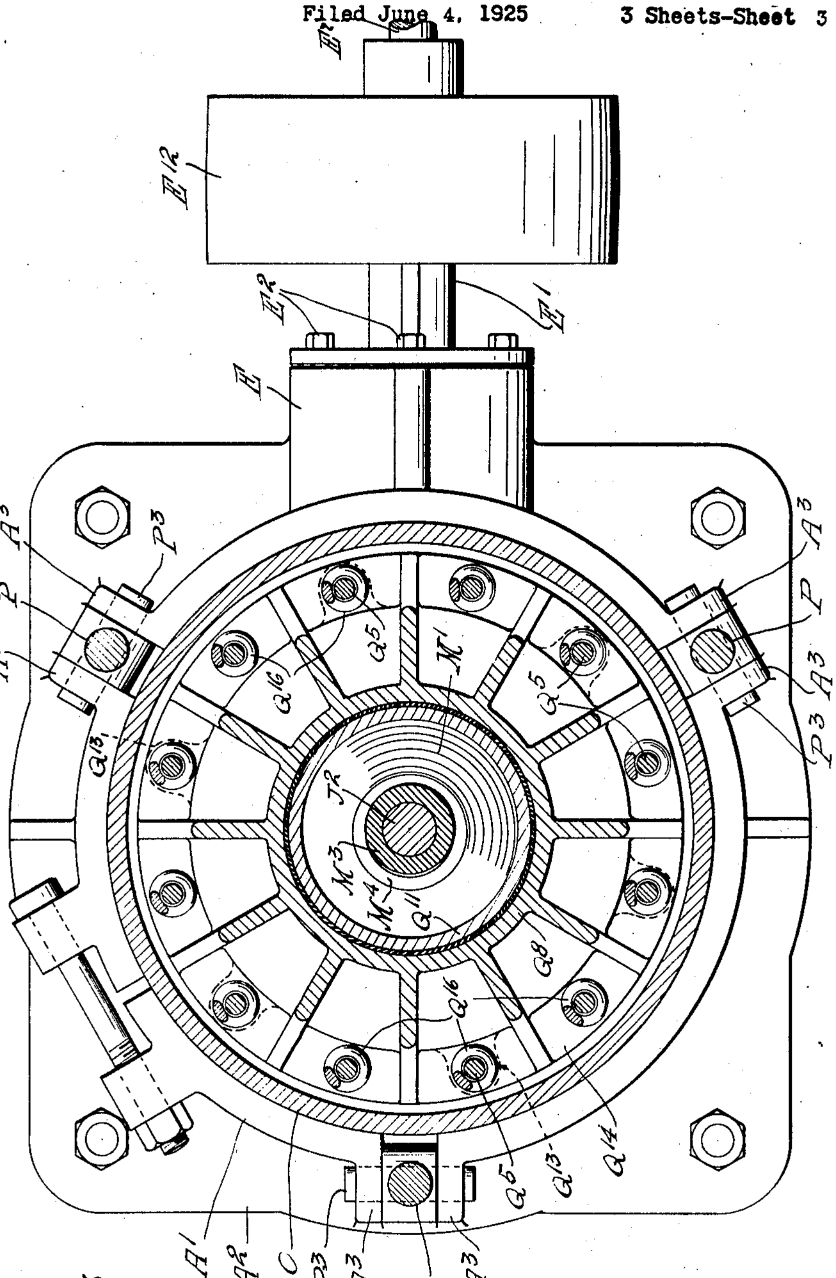

Fig. 3

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UNITED STATES PATENT OFFICE.

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GYRATORY CONE CRUSHER.

Application filed June 4, 1925. Serial No. 34,795.

My invention relates to improvements in gyratory coal crushing machines of the type in which the material to be crushed is fed, or is allowed to flow by gravity, through a crushing zone between a normally fixed concave and a cone gyrating within the concave.

One object of my invention is to provide a new and improved type of gyratory crusher adapted for fine crushing. Another object is to provide such a crusher wherein means are provided to permit a very fine adjustment of cone and concave. Another object is to provide opposed yieldingly supported crushing elements in such a crusher. Another object is to provide a yieldingly supported crushing concave. Another object is to provide a gyratory crusher for fine reduction, which can be set for small sizes of output without risk of stoppage or breakage upon the passage through the crushing zone of relatively large masses of uncrushable material. Another object is to provide a simple and effective oiling system to prevent the entry of dust, water or other foreign materials into the bearings, and to prevent oil leakage.

Other objects will appear from time to time in the course of the specification and claims.

My invention is illustrated more or less diagrammatically in the accompanying drawings, wherein—

Figure 1 is a vertical axial section with parts broken away;

Figure 2 is a detail section of the portion not shown in Figure 1;

Figure 3 is a sectional plan view section on the line 3—3 of Figure 1;

Figure 4 is a vertical axial section of the upper part of the crusher showing a modified construction; and

Figure 5 is a detail section of a variant type of concave.

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

A is a bed or support upon which rests a frame A^1 provided at its base with the horizontal reinforcing flange A^2 and strengthened by the vertical reinforcing flanges A^3. Projecting inwardly from the frame A^1 are the radial flanges or ribs or frame members A^4, which join and support the central cylindrical housing B.

The housing or cylinder B is outwardly expanded adjacent its upper end, as at B^1. A suitable bearing member or sleeve B^2, of suitable anti-friction material, for example bronze, penetrates the upper end of the cylinder, its outwardly projecting flange B^3 resting upon the top B^4 of the cylinder.

The bottom of the cylinder is closed, for example by the cap; C, which may be bolted as at C^1, and which supports the lower bearing sleeve or anti-friction member C^2. The top of the cap C is provided with any suitable anti-frictional surfacing, herein illustrated as the inset blocks C^3, of any suitable but preferably highly wear resistant anti-frictional metal, for example, bronze.

Penetrating the cylinder B in bearing contact with the sleeves B^2 and C^2 is the eccentric sleeve D. It is provided at its upper end with the outwardly projecting ring gear D^1 inclosed within the space defined by the wall B^1 and projecting outwardly and downwardly beyond the upper edge B^4 of the cylinder. It is provided at one point in its periphery with the upwardly hollow enlargement D^2, adapted to receive a variable quantity of lead or other heavy material D^3.

The sleeve D is eccentrically apertured from the top to the bottom, the aperture comprising, for example, an upper bore D^4 of maximum diameter, an intermediate bore D^5 of intermediate diameter, and a lower bore D^6 of minimum diameter, beneath which is the somewhat enlarged aperture or depression D^7 in the bottom of the shaft. The several bores or stages are co-axial and are aligned along an axis both eccentric to and inclined to the axis of the cylinder B, but intersecting such axis at the point X, the significance of which will appear later.

The sleeve D is supported by the rotating plate D^{10}, which rests upon the pads or blocks C^3. It is centrally apertured as at D^{11}, and is provided with an eccentric stud or upward projection D^{12} adapted to engage the opposed aperture D^{13} in the bottom of the sleeve D.

The cylindrical housing B is at one side provided with the outwardly projecting shaft housing E, herein shown as integral with it. Mounted there-within is the shaft supporting sleeve E^1 bolted to the main frame, for example, as at E^2. The sleeve E^1 is enlarged or socketed at either end, as at E^3, E^4, to receive the anti-frictional bearings or bushings E^5, E^6. Mounted in said bearing is the drive shaft E^7, to the inner end of which is keyed the beveled pinion E^8 in mesh with the gear D^1. The outer bushing E^6 is contacted by the ring E^9, of angular cross-section, which in turn is surrounded by the flanged plate E^{10} bolted to the outer end of the sleeve E^1. E^{12} is a pulley keyed to the shaft E^7.

The shaft continues beyond the bearing E^6 and the pulley E^{12}, being received in the bearings G, G^1, suitably mounted upon the support G^2. G^3 is a housing or casing integral with such support and housing the beveled pinion G^4 keyed to the shaft E^7. In mesh with it is the beveled pinion G^5 keyed to the vertical shaft G^6 housed within the support G^2. At the lower end of said shaft G^6 is any suitable rotary oil pump, herein diagrammatically illustrated as at G^7.

The top of the housing B is closed by the cover plate H, which is provided with the spherical bearing portion H^1, herein shown as of some suitable anti-friction material, such as bronze, which may be removed and renewed. Surrounding the bearing portion H^1 is the circumferential well or sump H^2, beyond which is the spherical bearing portion H^3 provided with any suitable washer or oil wiping member H^4. H^5 is a passage from the sump H^2 adapted to deliver the oil contained therein to the parts inclosed by the housing B^1.

Mounted in the eccentric D is the shaft J, comprising an intermediate tapered portion J^1, an upper cylindrical portion J^2 of minimum cross-section, a central cylindrical portion J^3 of maximum diameter, and the cylindrical sections of progressively reduced diameter, J^4 and J^5. The portions J^3, J^4 and J^5 of the shaft are contained within the portions D^4, D^5 and D^6, respectively, of the aperture of the eccentric D. The shaft is axially apertured as at J^6, the aperture extending from the bottom of the shaft to a point within the inclined portion J^1. J^7 is an oil passage extending laterally from it to the outside of the shaft adjacent its top. J^8 and J^9 are similar lateral oil ducts positioned, respectively, just beneath the termination of the cylindrical sections J^3 and J^4.

The shaft axially engages the sleeve K of bronze or other suitable anti-friction material. The cross-section of its interior aperture conforms to the cross-section of the various portions of the shaft, but the aperture of corresponding bore in each case continues below the termination of the corresponding cylindrical shaft section, as at K^1 and K^2. The open spaces so formed are aligned with the oiling ducts J^8 and J^9, respectively. K^{10} is an oiling passage in the eccentric D aligned with the oiling duct J^9 and the annular space K^2 and communicating with the interval or space K^{12} between the upper and lower anti-friction members B^2 and C^2. K^{14} is a vertical key extending from top to bottom of said sleeves. K^{16} is a vertical key let in the inside surface D^4 of the eccentric D, and adapted to prevent relative rotation of the sleeve K and the eccentric D.

L is a crushing cone seated upon the tapered portion J^1 of the shaft. It is provided with an integral spherical bearing portion L^1, adapted to conform to and to engage the opposed spherical bearing surface H^1 on the cap H. It is provided with an integral downwardly and outwardly projecting skirt L^2, inwardly projecting from which is the annular flange L^3 provided with the spherical bearing surface L^4 concentric with the surface L^1 and adapted to engage the packing H^4 of the member H^3. The surface L^1 is broken by a circumferential oil duct L^6, which is connected by means of the radial duct L^7 with the central aperture of the cap H. The hollow interior L^{10} of the head communicates with the oil duct J^7 and is provided with an oil duct L^{12} leading to the circumferential oil channel or duct L^6, at an angle of 180° from the duct L^7.

M, M^1 are mantle members mounted on the head L and directly contacting, for example, the zinc layer M^2. M^3 is a securing sleeve slidable along the upper cylindrical portion J^2 of the shaft and provided with a downwardly and outwardly flaring or conic portion M^4, adapted to engage the upper edge of the mantle section M^1, but normally out of engagement with the head L. The upper end of the shaft is screwthreaded, as at M^5, and is surrounded by the locking sleeve or nut M^6, screwthreaded in conformity with it. M^7 are handles or turning studs whereby the nut M^6 may be rotated to exert a downward thrust against the sleeve M^3, and thus against the mantle section M^1 and the head L. M^8 is any suitable key member adapted to be inserted between the nut M^6 and the screw-threaded portion of the shaft, to prevent their further relative movement.

The upper end of the shaft is axially apertured as at N, to receive the stub N^1 of the deflector plate N^2. The plate consists of the central spherical portion N^3 concentric with the bearing surfaces L^1 and L^3, their common center being the point indicated as X. N^4 is a relatively flattened rim outwardly projecting from the spherical portion N^3. The deflector plate is preferably but not necessarily a casting.

Slidably mounted within the lower fixed frame portion A^1 is the upper axially movable frame member O. It is provided with a plurality of outwardly projecting ears O^1, preferably three in number, apertured as at O^2, the upper and lower portions of such apertures being beveled as at O^3, O^4. P are securing bolts pivoted as at P^1 to the fixed frame member A^1. The base portion is apertured as at P^2, to permit the passage therethrough of the transverse securing member P^3, which passes, for example, also through adjacent flanges A^3 of the frame A^1. Mounted on the bolt P are the upper and lower securing nuts P^4, P^5, beveled to conform to the beveled surfaces O^3 and O^4. It will be understood that the bolt P is of smaller cross-section than the aperture O^2. P^6 is any suitable key or locking member adapted to prevent rotation of the nut P^5. The member O terminates in an inwardly turned flange O^{10}, upwardly beveled as at O^{11}.

Resting upon the upper edge of the member O is the ring Q, provided with the concentric beveled-walled grooves Q^1, Q^2, the outer of which conforms generally to the shape of the upper edge of the frame member O. The ring Q is centrally flanged as at Q^3 about its interior aperture, and is provided with the strengthening ribs Q^4. It is apertured at a number of properly spaced points to permit the passage therethrough of the bolts Q^5, supported in position, for example by the nuts Q^6. Supported by said bolts within the member O is the ring Q^7, supporting the concave Q^8, and provided with the circumferential ridge Q^9 conforming generally to the shape of the groove Q^2 of the ring Q. Q^{10} is any suitable cover plate for the ring Q and Q^{11}, Q^{12} are separate mantle sections supported in position, for example by the outwardly projecting ears Q^{13} mounted upon the bolts Q^5. The mantle section Q^8 terminates in a circumferential flange Q^{14}, through which pass the bolts Q^5. Q^{15} is a stop ring of angular cross-section adapted to be seated against the flange O^{10} of the frame or housing portion O. Q^{16} are spiral springs adapted to be compressed between the flange Q^{14} and said ring Q^{15}. The bolts P are upwardly reduced as at R, and are provided with supporting nuts R^1, upon the upper surfaces of which seat the terminal portions R^2 of the arms R^3 which support the ring R^4 of the apron R^5. The apron is preferably, although not necessarily, formed of flexible material, such as belting. R^6 is the centrally positioned feed spout connected to the ring R^4 in any suitable manner, and R^7 is any suitable cover plate. R^8 is a housing, for example of sheet iron, seated upon the flange Q^3 of the ring Q and upwardly projecting about the flexible apron R^5. R^{10} is any suitable key adapted to prevent rotation of the nut R^1.

S is any suitable oil tank, from which extends the oil feed line S^1, through which oil may be passed, for example by the rotary pump G^7 earlier described. The oil line S^1 extends to the cap C and through the passage S^2 therein and through the central aperture S^8 and the aperture D^{11} through the plate D^{10}. S^{10} is the return line passing through the shaft housing E, through the pipe section S^{12}, and thereby back to the oil tank S. It communicates with the space S^{14}, in which is positioned the beveled pinion E^8. S^{16} is a ledge formed in the upper part of the same chamber and communicating by an oil duct S^{18} with the bearings of the shaft E^7.

It will be realized that whereas I have described and shown an operative device nevertheless many changes may be made in the size, shape, number and disposition of parts without departing from the spirit of my invention, and that I therefore wish my drawings and description to be taken as in a broad sense illustrative, rather than as limiting me to my specific showing.

In the alternate form shown in Figure 4, I illustrate a type of crusher in which the cone as well as the concave is yieldingly mounted.

The bearing cap a is spherically formed upon its upper side as at c and supports a babbitt facing c^1, which provides a non-frictional supporting surface for the opposed spherical bearing surface c^2 of the head c^3. The head c^3 is centrally apertured, and seats upon the upper tapered surface c^5 of the gyratory shaft c^6, the lower section c^7 of which penetrates within the eccentric aperture of the sleeve b and is mounted within an inner babbitt bearing c^8. The head is provided with a skirt c^{10} bolted or otherwise removably secured to the ledge c^{11} about the head and terminating in a spherically surfaced flange c^{12} adapted to engage the oil packing ring c^{13} in a spherical bearing surface c^{14} which is concentric with the main spherical bearing.

The upper end of the head is surrounded by a ledge d which is arcuate in cross-section as at d^1, the arcuate portion forming a bearing or tilting support for the open bottomed, hollow crushing cone d^2, which is inwardly flanged at the top, as at d^3, about its central aperture, to conform generally to the shape of the ledge. The periphery of the cone is reinforced, for example, by a cylindrical section d^4, although other reinforcing might be used.

Mounted upon the hollow cone is a mantle comprising a plurality of conical rings e, e^1, which may be of manganese steel or other suitable material. e^4 is a securing or pressure transmitting ring adapted to engage the uppermost manganese ring and to conform to its angular irregularities. The manganese rings may rest directly upon the mantle but are preferably supported upon a layer of zinc or other suitable material e^5.

I provide unitary means for holding the head upon the shaft, the cone upon the head, and the mantle upon the cone. The lock nut g is screwthreaded upon the upper portion of the shaft c^6 and may be locked in position, for example by the key g^2. Between it and the mantle cone and head are compressed a plurality of sets of powerful springs, comprising an outer spiral spring g^3 and an inner spiral spring g^4, the outer and inner springs being of opposite pitch. These sets of springs are compressed between the opposed spring seats g^5, g^6. The spring seat g^5 is seated by the pressure of the spring against the lock nut g and is provided with a downwardly projecting sleeve g^7, in which are a plurality of apertures g^8. Upwardly projecting from the lower spring seat g^6 is a central sleeve g^{10}, the upper end of which is provided with teeth or lugs which mesh with the apertures g^8 and prevent relative rotation of the two spring seats. The bottom of the spring seat g^6 is provided with a spherical bearing surface g^{11} opposed to and conforming to the spherical surface g^{12} of the ring g^{13}, the bottom of said ring g^{13} being in engagement with the top of the ring e^4. Projecting upwardly and slightly outwardly from the ring g^{13}, and surrounding the springs, is the cylindrical or slightly conical casing h, which supports the feed plate h^1, the upper surface of which forms a very flat cone. The plate h^1 is positioned above and out of contact with the nut g and the top of the shaft c^6. It will be understood that the cone, mantle and feed plate can move only as a unit, owing to the pressure of the springs g^3, g^4.

The use and operation of my invention are as follows:

When the machine is set up as shown in the drawings the drive shaft is rotated and causes the eccentric sleeve to rotate in its bearing. As the eccentric rotates it gyrates the shaft, and through the shaft it gyrates the cone or crushing head about its large spherical bearing. Upon the cone is mounted the mantle which actually engages the material being crushed. The mantle portions are seated upon the cone and the cone is seated upon the shaft by means of the clamping sleeve and the screwthreaded nut.

Since I use my crusher for fine reduction and wish to set the cone very close to the mantle, I provide a yielding release which will permit the passage through the crushing zone of uncrushable material, when by any chance it passes therethrough, without either stopping the machine or causing breakage. I obtain this result by providing a spring release for the crushing concave. I suspend the concave by means of a set of bolts passing through the plate or ring Q and depending from it and passing through the circumferential flange Q^{14} about the bottom of the concave. The mantle is locked in position by the same bolts by means of the ears Q^{13}, through which the bolts also pass. The strength of the spiral springs Q^{16} is such that, under all normal conditions, the concave is fixed in position and will not be moved at all by the pressures incident to normal crushing operation. However, the springs are sufficiently yielding to permit movement of the concave when unbreakable material passes through, and they will yield sufficiently rapidly to prevent breakage of any of the parts or stoppage of the machine. The ring Q^7 is normally drawn up by the bolts into such position that the beveled flange Q^9 is seated within the beveled-walled groove Q^2, and the ring Q^7 or concave and the grooved ring Q will from that time on act as one piece. If a non-crushable substance is introduced between the cone and the concave, causing the concave to be lifted on one side, the flange Q^{14} will raise and compress the springs, because the angle ring Q^{15} is held rigidly to place by the holding bolts Q^5 and the flange O^{10}. The concave and the ring Q lift as a unit and pivot about a point diametrically opposed to the location of the interfering object, the beveled-upper edge of the ring O serving as the pivot. Thus, if a piece of iron passes through the crushing zone, the concave, instead of cracking, will tilt, and it will tilt before the machine can be stopped by the obstruction. If the material being crushed is damp and compresses into an uncrushable mass, the machine will not tend to stop, as is the case with unrelieved crushing members, but the only unfavorable result will be that a little over-size and a few flakes of compressed material will pass through the crushing zone.

The material to be crushed is fed in from above, falling freely under gravity into the crushing space between the concave and the cone. As the cone gyrates, the material being crushed will be wedged or pinched between it and the concave and each particle, as soon as it has been crushed, will commence to fall freely away from the concave, the distance of its fall depending on the relation between the acceleration due to gravity, the rate and length of gyration of the cone, and the size of the particle. The particles will fall vertically until they strike the cone and will then be deflected outwardly and downwardly until they reach a point at which the distance between the cone and concave, at the distance the particles arrive, is equal to the diameter of the particular particles. At this point the downward movement of the particles ceases until they have been crushed and released, and the process is repeated in a sequence of similar successive drops, lateral conveying excursions, and actual crushing excursions.

Vertical adjustment of the concave is provided by means of a plurality of adjusting screws, preferably three in number. These screws are pivoted upon a fixed base A^1 but are held normally in vertical position. They loosely engage the apertures of the flanges of the vertically movable frame member O. The said frame member is adjusted for height in the following manner: The lower nuts P^4 are positioned at the desired height and the frame member O is lowered into contact therewith. The upper nuts P^5 are then rotated into proper position and locked against further movement, for example by the keys P^6. When it is desired to make an adjustment of the frame member O, it can be done by successively adjusting its relation with each of the holding bolts. In such case the upper nut P^5 is released and moved upwardly along the bolt to the desired height, and the ear O^1 is raised to contact the bottom of the nut P^5, and the nut P^4 is then screwed up to the proper position. Since there is something of a play between the apertures of said ears and the supporting bolts, it is possible to make the adjustments one at a time, without even stopping the operation of the crusher.

The material to be crushed may, if desired, be permitted to accumulate in any suitable species of hopper or container above the cover plate R^7. In any case the material flows through the central aperture and forms a column resting on the feed or deflector plate N^2. This column is of generally conic form and material from its base is continuously fed outwardly by the rotation and gyration of the plate. The cover plate may be vertically adjusted along the reduced portions R of the supporting bolts P, as shown, in order to regulate the flow of material to the feed plate. When so adjusted the feed plate will feed a substantially constant volume of material to the crushing zone, the material being delivered substantially uniformly about the annular entrance into the crushing zone, the point of maximum feed being the lowest point of the edge of the plate, and moving around the plate as the plate is gyrated.

By making the apron R^5 flexible, I prevent any tendency of binding or wear between said apron and the housing R^8, which is preferably fixed in relation to the ring Q and, of course, moves with it when the ring Q is tilted in response to the passage of uncrushable material through the crushing zone.

The oiling system is simple and entirely concealed and internal, the oil being supplied to all bearings from a single oil reservoir. Oil is pumped in any suitable manner from the oil tank upwardly through the central aperture J^6 of the shaft J. The oiling connection is constant, since the plate D^{10}, which supports the bottom of the eccentric D, is centrally apertured in line with the central oiling aperture S^3. Oil passes upwardly through the length of the shaft J and then laterally outwardly, through the oil duct J^7, into the central space of the head. It passes downwardly therethrough by the oil duct L^{12} to the circumferential oiling ring or passage L^6, formed in the spherical bearing surface L^1 of the head. Oil is wiped back and forth across the opposed antifrictional spherical member H^1, and also flows inwardly along the duct L^7, formed in the surface of the head, to the central aperture of the cap H. The groove L^7 is cut in the bottom of the spherical surface or ball along a radius 180° removed from the point of connection between the oil duct L^{12} and the circumferential passage L^6. This allows the oil to spread under the wearing surfaces as the head is gyrated, the overflow returning to the central oil cavity along the duct L^7. To oil the inner eccentric bearing, I provide two oil ducts, J^8 and J^9, which permit the oil to pass outwardly from the central pasage J^6.

In order to carry out the characteristic crushing function of my device, an excursion or throw of the crushing head is desired many times that of the normal gyratory crusher, and in order to balance this large throw I provide a counterweight consisting of a flange cast on a gear and adapted to receive the lead or other heavy metal. By determining the number of pounds that is to be used as a balance weight, the weight of lead necessary can be predetermined and the desired quantity is melted and poured into place.

The deflector or distributing plate N^2, which is preferably but not necessarily a casting, is formed with a spherical center portion, the center of the spherical portion being the intersection of the axes of the shaft J and the cylindrical central housing B, viz: the point X. One object in providing a distributing or deflector plate of spherical form is to prevent any tendency of that portion of the plate which is positioned under the edges of the feed spout R^6 from rising and falling, causing the feed spout and the cover plate R^7 to be lifted with the material.

The deflector plate is made of substantially the same or even of slightly greater diameter than the upper opening to the crushing cavity. The purpose of this is to prevent material dropping from the edge of the deflector plate to the surface of the cone and thus acquiring excess speed and momentum. The fall of the material is preferably broken, for example by the plate Q^{10}. In practice the particles are caught upon the plate Q^{10} and when relatively fine material is being fed, they build up until they flow inwardly and downwardly along the angle of repose of the material so accumulated. The particles thus incline inwardly as they fall and tend to strike the apex of the cone.

It will be noted that the concentric apertures of the grooved ring Q are beveled and made to fit the opposing portions of the member O and the ring Q^7 on two sides. This is done to prevent the ring Q from becoming worn. The joint tends to wear into a fit rather than out of a fit, so that in an older machine there will be no more play than in a new machine.

Also, the flanges Q^9 and O^{10} are sufficiently truncated to avoid contact with the bottoms of the opposed groves Q^1 and Q^2. Sufficient space is allowed so that the opposed inclined surfaces will always be in contact, even through the metal may stretch and wear.

Whereas in the form of Figure 1 relatively large material may be reduced to varying fineness with a minimum of fines or degradation and a minimum of contact between particle and particle, in the form of Figure 5 I am able to convert my crusher into a pulverizer, by merely varying the angular relation of cone and concave. In the form shown I provide a cone and concave the crushing surfaces of which are parallel substantially from top to bottom. I preferably feed to the crushing zone relatively fine material. For example I may feed to it material finer than the maximum opening at the top of the crushing zone, and when so used my crusher may be employed to replace the so-called intermediate crushers. It will take material already reduced to any size below say ¾ of an inch, for example, and will break it up by repeated impacts of cone against bowl, the material being thus reduced by successive crushing strokes each terminating in an equal and very close approach of cone to concave, although the actual carrying stroke increases from top to bottom of the cone. The material is finely reduced by the successive impacts, and packs into clods or flakes of fine particles. As they are released, the flakes drop upon the cone and are broken up, and again recrushed. The clodding or packing and the repeated impacts, each impact terminating in a close approach of cone to concave, result in a maximum grinding or crushing of particle against particle, and the product is practically a powder. Owing to the spring release the cone and concave may be set practically to contact from top to bottom. When the concave yields, it rotates about a point on the opposite side of the concave from that where the compression is taking place. Since the cone is either fixed on the crushing head or rotates about a different center, the result is a lateral movement of concave in relation to cone which causes a very effective grinding action.

I claim:

1. In a gyratory crusher, a crushing cone and means for gyrating it, a concave surrounding said cone and a fixed support therefor and yielding means for holding said concave normally in fixed position against such support, said means being adapted to permit movement of said concave in response to a predetermined pressure thereagainst in excess of normal crushing pressure.

2. In a gyratory crusher, a crushing cone and means for gyrating it, a concave surrounding said cone and a fixed support therefor and yielding means for holding said concave normally in fixed position against such support, said means being adapted to permit lateral movement of said concave in response to a predetermined pressure thereagainst in excess of normal crushing pressure.

3. In a gyratory crusher, a crushing cone and means for gyrating it, a concave surrounding said cone and yielding means for holding said concave normally in fixed position, said concave being mounted for tilting movement in response to a predetermined pressure thereagainst.

4. In a gyratory crusher, a frame, a cone supported by said frame and means for gyrating it, a concave supported by said frame, and a connection between said concave and said frame, normally rigid, but adapted to permit yielding movement of concave in relation to frame, in response to predetermined pressure against the crushing face of the concave.

5. In a gyratory crusher, a crushing frame, a cone mounted therein and means for gyrating it, a tiltably mounted concave surrounding said cone, and a yielding connection between said concave and said frame comprising a plurality of springs compressed between said concave and the frame.

6. In a gyratory crusher, a crushing frame, a cone mounted therein and means for gyrating it, a tiltably mounted concave surrounding said cone, and a yielding connection between said concave and said frame comprising a plurality of vertically disposed coil spring compressed between said concave and said frame.

7. In a gyratory crusher, a crushing frame, a cone mounted therein and means for gyrating it, a tiltably mounted concave surrounding said cone, a yielding connection between said concave and said frame comprising a plurality of springs compressed between the lower edge of said concave and said frame, supporting bolts aligned with said springs and adapted normally to support the lower edge of said concave, and a

circumferential ring member, through which said bolts pass, in tiltable relation with the upper edge of said frame.

8. In a gyratory crusher, a circumferential frame, a cone mounted within said frame and means for gyrating it, an inverted bowl surrounding and overhanging said cone, a supporting connection between said bowl and said circumferential frame comprising in part a supporting ring resting upon said frame, supporting members connecting said ring and said bowl, and yielding means interposed between said bowl and said frame and adapted normally to constrain said bowl and said supporting ring to their lowest possible positions in relation to the frame.

9. In a gyratory crusher, a crushing cone, a member upon which it is supported and means for gyrating it, a concave surrounding said cone, said concave being normally fixed in position, said cone being normally fixed in relation to the member upon which it is supported, holding means adapted to permit relative movement of said cone in relation to its supporting member, and holding means adapted to permit relative movement of said concave in relation to the crusher, in response to predetermined pressures thereagainst.

10. In a gyratory crusher, a crushing cone, a member upon which it is supported and means for holding the cone normally in rigid relation with said member, means for gyrating said cone supporting member, a concave surrounding and overhanging said cone and a supporting member therefor, said concave being normally in rigid relation with said supporting member, and means interposed between said cone and its supporting member and between said concave and its supporting member, adapted to permit movement of said cone and said concave in relation to said supporting members, in response to predetermined pressures in the crushing zone.

11. In a gyratory crusher, a crushing frame, a concave yieldingly mounted on said frame, a cone within said concave, and means for gyrating it, said cone being yieldingly mounted.

12. In a gyratory crusher, a frame, an eccentrically apertured sleeve mounted therein and means for rotating it, a gyrating shaft adapted to penetrate the aperture of said sleeve, said shaft and sleeve having a plurality of opposed, stepped bearing surface sections of successively smaller diameter.

13. In a gyratory crusher, a frame, an eccentrically apertured sleeve mounted therein and means for rotating it, a gyrating shaft adapted to penetrate the aperture of said sleeve, said shaft comprising a plurality of generally cylindrical stepped sections of successively smaller diameter, the aperture of said sleeve being stepped to conform thereto.

14. In a gyratory crusher, a frame, an eccentrically apertured sleeve mounted therein and means for rotating it, a gyrating shaft adapted to penetrate the aperture of said sleeve, said shaft comprising a plurality of stepped sections of successively smaller diameter, the successive stepped portions of the shaft being spaced from the corresponding ledges intermediate the successive stepped portions of the aperture.

15. In a gyratory crusher, an upwardly tapered gyratory shaft, a one-piece conic head seated on said tapered portion, the shaft including a cylindrical portion positioned above the tapered portion, a mantle member seated upon the conic surface of said head, a securing sleeve slidably mounted upon said cylindrical shaft portion and engaging the upper edge of said mantle portion, and means for thrusting it downwardly along the cylindrical portion of the shaft.

16. In a gyratory crusher, an upwardly tapered gyratory shaft, a one-piece conic head seated on said tapered portion, the shaft including a cylindrical portion positioned above the tapered portion, a mantle member seated upon the conic surface of said head, a securing sleeve slidably mounted upon said cylindrical shaft portion and engaging the upper edge of said mantle portion, and means for thrusting it downwardly along the cylindrical portion of the shaft, comprising in part a securing nut screwthreaded to the upper portion of said shaft.

17. For use with a gyratory crusher, a feed limiting plate comprising a central upwardly convex spherical portion and a surrounding rim.

18. For use with a gyratory crusher, a feed limiting plate having an upwardly convex spherical upper surface.

19. In a gyratory crusher, the combination with a gyratory shaft and means for gyrating it of a deflector plate and a central stem downwardly extending from said plate, the upper end of the shaft being axially apertured to receive it.

20. In a gyratory crusher, a crushing cone and means for gyrating it, a spherical bearing for said cone, a deflector plate, mounted above said cone, having an upwardly convex spherical surface, the spherical surface of said plate being concentric with the spherical bearing of the cone.

21. In a gyratory crusher, a crushing cone and means for gyrating it, a spherical bearing for said cone, a deflector plate, mounted above said cone, having an upwardly convex spherical surface, the spherical sur-

face of said plate being concentric with the spherical bearing of the cone, a rim surrounding the spherical portion of said plate and a feed chute vertically aligned above said spherical portion.

22. In a gyratory crusher, a main frame, a crushing concave and a vertically adjustable supporting member therefor, apertured ears outwardly projecting from said supporting member, a plurality of holding bolts pivoted upon said main frame and adapted to penetrate the apertures of said ears, and means associated with the main frame for constraining said bolts to vertical position.

23. In a gyratory crusher, a main frame, a crushing concave and a vertically adjustable supporting member therefor, apertured ears outwardly projecting therefrom, a plurality of holding bolts pivoted upon said main frame and adapted to penetrate the apertures of said ears, means for constraining said bolts to vertical position, adjusting and supporting nuts screwthreaded upon said bolts above and below said ears, and means for holding them against rotation.

24. In a gyratory crusher, a gyratory shaft, an eccentrically apertured sleeve adapted to rotate it, a gear associated with said sleeve and a counterweight associated therewith comprising an upwardly open receptacle adapted to receive molten metal.

25. In a gyratory crusher, a gyratory shaft, an eccentrically apertured sleeve adapted to rotate it, a gear associated with said sleeve and a counterweight associated therewith comprising an upwardly open receptacle adapted to receive molten metal, said receptacle being formed integrally with said gear.

26. In a gyratory crusher, a centrally disposed bearing housing, an eccentrically apertured sleeve positioned within it and means for rotating it, supporting means for said sleeve comprising a plate secured to the bottom of said housing and a bearing connection between said plate and the bottom of said eccentric sleeve.

27. In a gyratory crusher, a centrally disposed bearing housing, an eccentrically apertured sleeve positioned within it and means for rotating it, supporting means for said sleeve comprising a plate secured to the bottom of said housing, and a bearing connection between said plate and the bottom of said eccentric sleeve comprising friction reducing means on the upper side of said plate, a disk adapted to rotate thereupon and a supporting connection between said disk and said eccentric sleeve.

28. In a gyratory crusher, a centrally disposed bearing housing, an eccentrically apertured sleeve positioned within and means for rotating it, supporting means for said sleeve comprising a plate secured to the bottom of said cylinder, and a bearing connection between said plate and the bottom of said eccentric sleeve comprising friction reducing means on the upper side of said plate, a disk adapted to rotate thereupon, a supporting connection between said disk and said eccentric sleeve, and means for preventing relative rotation of said disk and said sleeve.

29. In a gyratory crusher, a cone and means for gyrating it, a concave surrounding said cone, a deflector plate positioned above said cone, a housing mounted thereabout, a feed spout positioned above said deflector plate and means for adjusting it in relation thereto, and a flexible apron associated with said feed spout.

30. In a gyratory crusher, a cone and means for gyrating it, a concave surrounding said cone, a deflector plate positioned above said cone, a housing mounted thereabout, a feed spout positioned above said deflector plate and means for adjusting it in relation thereto, and a flexible apron associated with said feed spout and in telescopic relation with said housing.

31. In a gyratory crusher, a frame, a cone and means for gyrating it, a concave surrounding said cone, supporting means between said concave and said frame, yielding means adapted normally to hold said concave upon said supporting means in fixed relation to said frame but adapted to permit tilting of said concave in response to a predetermined pressure thereagainst.

32. In a gyratory crusher, a frame, a cone and means for gyrating it, a concave surrounding said cone, supporting means between said concave and said frame, yielding means adapted normally to hold said concave upon said supporting means in fixed relation to said frame but adapted to permit movement of said concave in response to a predetermined pressure thereagainst, and a tilting connection between the outer edge of said concave member and the upper edge of said frame.

33. In a gyratory crusher, a frame, a cone and means for gyrating it, a concave surrounding said cone, supporting means between said concave and said frame, yielding means adapted normally to hold said concave upon said supporting means in fixed relation to said frame but adapted to permit movement of said concave in response to a predetermined pressure thereagainst, a tilting connection between the outer edge of said concave member and the upper edge of said frame, the concave member being channeled to receive the upper edge of the frame, the bearing surfaces being inclined.

34. In a gyratory crusher, a crushing cone and means for gyrating it, and a concave surrounding said cone, the opposed surfaces of cone and concave being parallel throughout the greater part of their length, one of the opposed surfaces being flared away from

the other along the upper portion of the crushing zone defined by the opposed surfaces.

35. In a gyratory crusher, a pair of opposed crushing elements, the mean distance between which is substantially equal throughout the greater part of their length, comprising a crushing concave, a cone mounted therewithin, means for gyrating it, and yielding securing means for one of said crushing elements, adapted to permit it to move laterally away from the other in response to a predetermined pressure thereagainst.

36. In a gyratory crusher, a crushing cone and means for gyrating it, a concave surrounding said cone, the opposed surfaces of cone and concave being parallel throughout the greater part of their length, feed restricting means adapted to control the delivery of material to the crushing zone, and a yielding release associated with one of said crushing elements.

37. In a gyratory crusher, a crushing cone and means for gyrating it, a concave surrounding said cone, the opposed surfaces of cone and concave being parallel throughout the greater part of their length, and supporting means for such concave adapted to hold it normally against movement, but adapted to release it for movement away from said cone in response to a predetermined crushing pressure, said concave being mounted to tilt about a center on the side opposite the point of application of such crushing pressure.

38. In a gyratory crusher, a crushing cone and means for gyrating it, a concave surrounding said cone, and supporting means for such concave adapted to hold it normally against movement, but adapted to release it for movement away from said cone in response to a predetermined crushing pressure, said concave being mounted to tilt about a center on the side opposite the point of application of such crushing pressure.

39. In a gyratory crusher, a crushing cone and means for gyrating it, a concave surrounding said cone and supporting means for said concave adapted to hold it normally against movement, and to release it for movement away from said cone in response to a predetermined crushing pressure, said concave being mounted to move vertically in relation to said cone as it recedes laterally therefrom.

40. In a gyratory crusher, a crushing cone and means for gyrating it, a concave surrounding said cone and supporting means for said concave adapted to hold it normally against movement, and to release it for movement away from said cone in response to a predetermined crushing pressure, said concave being adapted to describe an arc, as it recedes from the cone, different from the path described by the cone.

41. In a gyratory crusher, a crushing cone, a spherical support for said cone and means for gyrating the cone, a concave surrounding the cone and supporting means for the concave adapted to hold it normally against movement, and to release it for movement away from said cone in response to a predetermined crushing pressure, said concave being adapted to describe an arc, as it recedes from the cone, eccentric from the center of rotation of the cone on its spherical support.

42. In a gyratory crusher, a crushing cone and means for gyrating it, an inverted concave surrounding and overhanging said cone, a feed restricting plate mounted on said cone, the diameter thereof being not less than the diameter of the upper aperture of the concave.

43. In a gyratory crusher, a main frame, a crushing concave and a vertically adjustable supporting member therefor, apertured ears outwardly projecting from said supporting member, a plurality of holding bolts pivoted upon said main frame and adapted to penetrate the apertures of said ears, and means associated with the main frame for constraining said bolts to vertical position, comprising transverse pins adapted to penetrate said holding bolts.

44. In a gyratory crusher, a crushing cone and means for gyrating it, and a concave surrounding said cone, the opposed surfaces of cone and concave being parallel throughout the greater part of their length, the concave being outwardly flared away from the cone along the upper portion of the crushing zone defined by the opposed surfaces.

Signed at Chicago, county of Cook and State of Illinois, this 22nd day of May 1925.

EDGAR B. SYMONS.