Nov. 26, 1935. R. C. NEWHOUSE 2,022,135

CRUSHER

Filed May 16, 1930 2 Sheets-Sheet 1

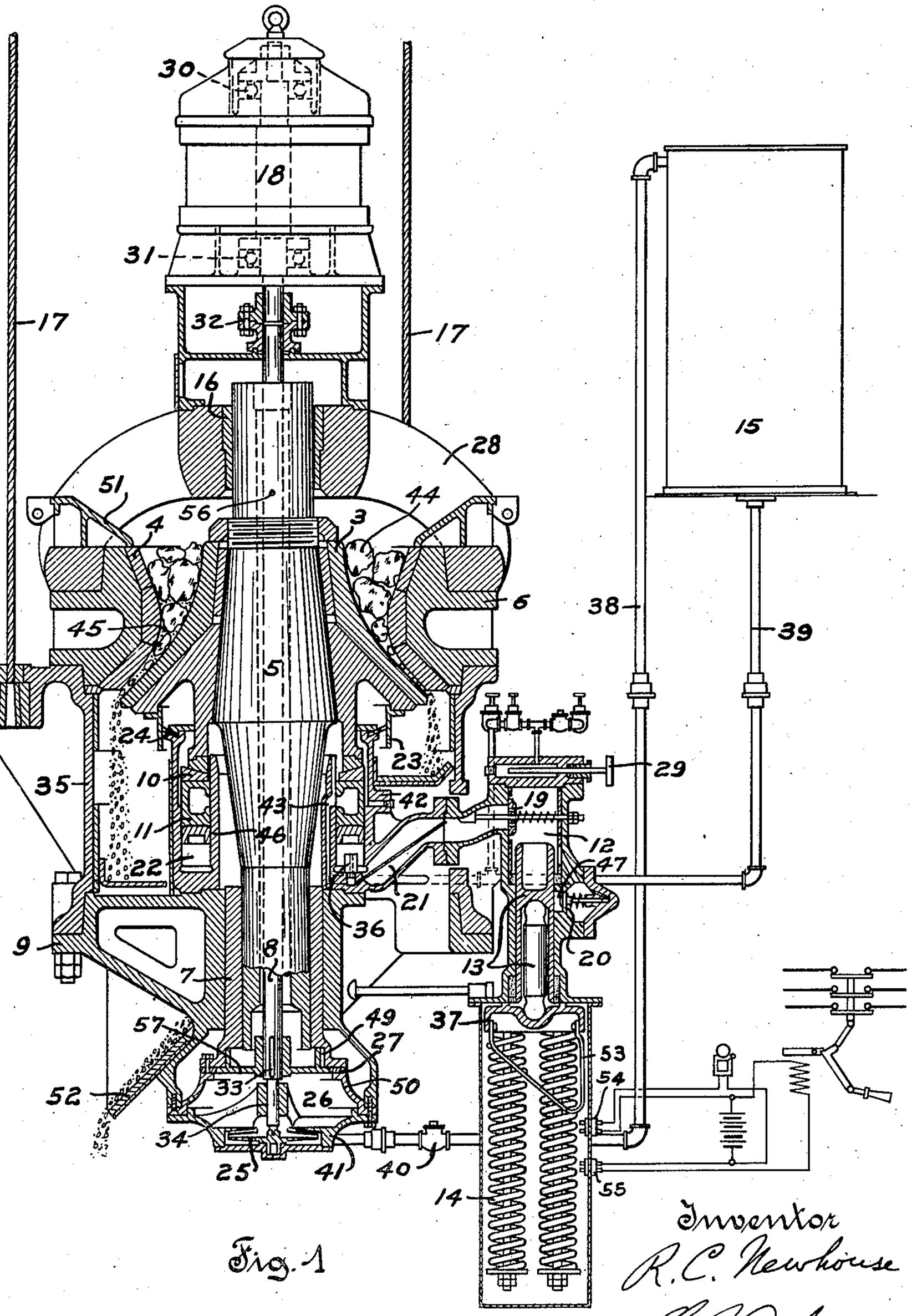

Fig. 1

Inventor
R. C. Newhouse
by
Attorney

Nov. 26, 1935. R. C. NEWHOUSE 2,022,135

CRUSHER

Filed May 16, 1930 2 Sheets-Sheet 2

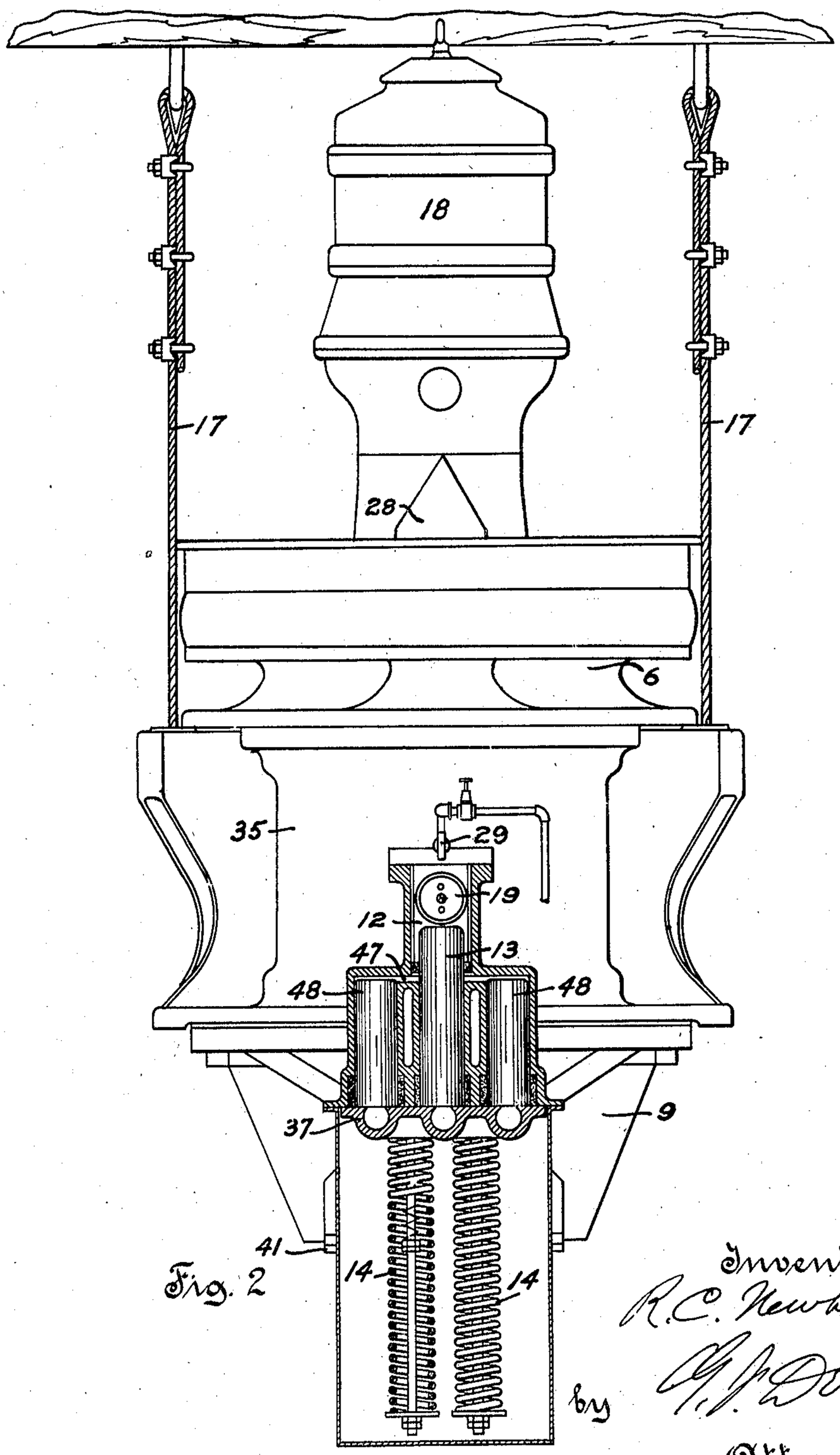

Fig. 2

Inventor
R. C. Newhouse
by
Attorney

Patented Nov. 26, 1935 2,022,135

UNITED STATES PATENT OFFICE

2,022,135

CRUSHER

Ray C. Newhouse, Wauwatosa, Wis., assignor to Allis-Chalmers Manufacturing Company, Milwaukee, Wis., a corporation of Delaware

Application May 16, 1930, Serial No. 452,864

19 Claims. (Cl. 83—10)

The present invention relates in general to improvements in the art of reducing material, and relates more specifically to improvements in the construction and mode of operating crushers for disintegrating variable sized lumps of relatively hard substances such as rock, ore, coal and the like, and for reducing such materials to a product comprising small pieces of relatively uniform size.

An object of the invention is to provide an improved crusher which is simple, compact and rigid in construction, and which will quickly and effectively reduce material to relatively uniform size.

It has heretofore been proposed to operate a gyratory crusher at relatively high speed in order to enhance the capacity thereof and to produce more uniform final product, than was obtainable with the old slow speed crushers of the gyratory type. In order to secure the desired capacity and uniformity of final product, a definite relationship must exist between the relative angularity of the crushing surface, the throw of the eccentric and the speed of rotation of the eccentric. This relationship must be such that all of the material advancing downwardly through the crushing zone between the receding cooperating portions of the crushing members, can contact only with one of the members and remains either free to drop by gravity, or freely slidable along one member, until the next crushing impulse or blow is applied.

A more specific object of the present invention is to provide various improvements in the details of construction and in the mode of operating crushers of this high speed type, whereby better reduction of the material results. Still another object of the invention is to provide a crusher of the gyratory type, having a wide range of reduction, and especially adapted for fine reduction purposes. Another object of the invention is to provide an improved high speed gyratory crusher which is operable at capacity feed to produce maximum quantities of relatively uniform product devoid of undesirable quantities of fines. Another specific object of the invention is to provide improved supporting means for the movable member of the crusher. A further specific object of the invention is to provide means for readily effecting relative adjustment of the crushing members so as to vary the size of the final product. Still another specific object of the invention is to provide an improved safety release for permitting separation of the crushing members so as to avoid damage to the crusher in case an abnormally hard piece of material is admitted to the crushing chamber, and means for effecting automatic return of the crushing members to normal operating position without shock to the crusher. Another specific object of the invention is to provide improved means for notifying attendants of abnormal conditions of operation, and for automatically stopping the crusher when dangerous conditions of operation are reached. A further specific object of the invention is to provide improved driving mechanism especially applicable to crushers of the gyratory type, and means for permitting convenient assembly and dismantling of such crushers. These and other objects of the invention will be apparent from the following description.

Crushers operable in accordance with the foregoing new principle, have been disclosed in copending applications now Patent No. 1,799,476, April 7, 1931 and Patent No. 1,799,477, April 7, 1931, and some of the novel features pertaining to the construction and operation of such high speed crushers, shown and described herein, form the subject of said patents. The novel lubricating system disclosed and not specifically claimed herein, likewise forms the subject of a copending application now Patent No. 1,956,584, May 1, 1934, and the pressure relieving means including the main and auxiliary pistons disclosed herein but not specifically claimed, forms the subject matter of a copending application now Patent No. 1,961,811, June 5, 1934.

A clear conception of embodiments of the various novel features constituting the present invention, in a crusher, and of the method of operating such machines, may be had by referring to the drawings accompanying and forming a part of this specification in which like reference characters designate the same or similar parts in the several views.

Fig. 1 is a central vertical section through an improved high speed gyratory crusher.

Fig. 2 is a side elevation of the improved gyratory crusher shown in Fig. 1.

As illustrated in Fig. 1, the improved gyratory crusher forming the subject of the present invention, comprises in general an inner conical gyratory crushing member or head 3; an outer crushing member or concave 4 surrounding the head 3 and cooperating therewith to form an annular crushing chamber 45, a relatively massive main shaft 5 rigidly attached to the head 3, a rotary eccentric 7 cooperating with the lower end of the shaft 5 and rotatable at high speed so as to impart rapid gyratory motion to the head 3; an electric motor 18 or the like above the crusher for

rotating the eccentric 7 at high speed; and suitable supporting structure for the various crushing and driving elements.

The concave 4 is supported directly within an upper annular frame 6 which carries a spider 28 having a central upper guide bearing 16 within which the upper extremity of the hollow main shaft 5 is journaled. The eccentric 7 gyrates the main shaft 5 about a fulcrum point 56 and is rotatably supported in a central guide bearing formed in the lower frame 9, this frame being rigidly associated with the upper frame 6, by means of an intermediate frame 35. A hopper 51 associated with the upper portion of the upper frame 6 and with the spider 28, forms an inlet opening for admitting unrestricted quantities of material 44 to the upper vertically directed portion of the crushing chamber 45, and the discharge portion of the crushing chamber is flared outwardly, being adapted to deliver crushed material by gravity to a discharge spout 52 supported upon the lower and intermediate frames 9, 35.

The inner crushing member or head 3 rests directly upon a thrust bearing comprising a floating ring element 10 having a spherical upper surface coacting with a wearing ring fastened to the lower extremity of the head 3, and also having a plane lower surface cooperable with and slidable upon an adjacent plane surface of an annular plunger 11. The plunger 11 is vertically movable to vary the discharge opening, between inner and outer annular walls 46, 42, the inner of which is of less height than the outer, and the walls 46, 42 cooperate to form an annular recess within which the plunger 11 is disposed. The thrust ring element 10 by virtue of its lateral movability relative to the plunger 11, functions to compensate for vertical adjustment of the head 3 relative to the fulcrum point 56, and always maintains a proper seating for the head upon the plunger 11, regardless of the vertical position of the head relative to the concave 4. The chamber 22 within the bottom of the annular recess and directly beneath the plunger 11, is filled with incompressible fluid such as oil, this chamber being connected with a fluid pressure source 12 by means of a conduit 21.

A check valve 19 having one or more relatively small fluid return openings therethrough, is interposed between the passage 21 and the fluid pressure source 12. The fluid is normally held in a fixed position within the source 12 by means of a piston 13 which is held in uppermost position by a plurality of coil springs 14. As long as the fluid remains undisturbed the pressure within the source 12 may vary between that sufficient to support the head 3, the shaft 5 and the connecting parts, and a predetermined pressure established by the springs 14 sufficient to crush the material being acted upon during normal operating conditions. The source 12, conduit 21 and chamber 22 cooperate to provide a fluid support for the floating thrust ring element 10, and the thrust element 10 is preferably located closely adjacent to the head 3 and above the eccentric 7. A suitable stop 36 may be provided for limiting the downward movement of the plunger 11 when the fluid pressure is released, and the outer wall 42 may be provided with a dust seal ring 24 cooperating with an annular apron 23 carried by the head 3, as shown in Fig. 1, in order to protect the thrust bearing and the eccentric beneath the head 3 from dust or other foreign matter.

Located on each side of and laterally adjacent to the main piston 13, is an auxiliary piston 48, all of these pistons 13, 48 reacting against a common supporting block 37 which also carries a contact member 53 cooperable with switches 54, 55. When the contact member 53 has been moved downwardly by the block 37 sufficiently to close the upper switch 54, an alarm such as a bell is automatically sounded, and when the downward movement of the member continues to a sufficient extent to close the switch 55, the circuit of the motor 18 is broken and the motor stops. The springs 14 constantly urge the block 37 in an upward direction, and upon compression of these springs a predetermined amount due to excess pressure created in the source 12, the plunger 13 may be forced downwardly sufficiently to enable fluid from the source 12 to enter a passage 47 through the packing bore portion for the plunger 13 and to thereby exert the full pressure of the source 12 upon the ends of the auxiliary pistons 48. A pump 29 may be provided for varying the quantity of fluid confined within the source 12, the conduit 21 and the chamber 22 in order to alter the crusher discharge opening, and a by-pass valve 20 serves to permit return of fluid from the passage 47 when the plunger 13 has re-entered the source 12 and before the plungers 48 have been returned to normal uppermost position.

The driving motor 18 has upper and lower anti-friction bearings 30, 31 one or both of which, due to the vertical disposition of the motor, serve as thrust bearings. The motor shaft is direct connected to the upper extremity of a relatively light central drive shaft 8 by means of a coupling 32, and the lower extremity of the drive shaft 8 is secured to an eccentric driving plate 57 by means of an inner key 33. The drive shaft 8 extends downwardly through a bore in the main shaft 5 and has its lower extremity journaled in a guide bearing 34 formed directly in a removable bottom plate or cap 41. The eccentric 7 is drivingly connected directly to the plate 57 by means of an outer key 49, and the thrust plate 27 secured to the eccentric 7 bears directly upon the thrust bearing 50 which is attached to the bottom of the lower frame 9 by bolts independently of the attachment of the cap 41 to this frame, thus permitting removal of the cap without disturbing the eccentric or its thrust bearing. The central opening in the thrust plate 27 is also sufficiently large to permit free downward removal of the driving plate 57 therethrough.

The lower extremity of the drive shaft 8 is drivingly but detachably connected to a centrifugal pump 25 which is operable only when the crusher is in operation. This pump 25 is adapted to deliver lubricant from the lubricant collecting chamber 26 past a check valve 40 and through a pipe 38, to the upper portion of a lubricant purifying and storage device 15. A pipe 39 leading from the lower portion of the device 15 communicates with a conduit 43 which is adapted to deliver lubricant to the top of the annular recess within which the thrust ring element 10 is confined, above the plunger 11. The pipes 38, 39 are preferably formed of considerable length and may be provided with flexible sections so as to permit the lubricant cleansing and storage device 15 to be placed upon a stationary support, while permitting free vibration of the crusher upon the suspension cables 17, without imparting vibration to the device 15.

During normal operation of the improved crusher, the electric motor 18 rotates the eccen-

tric 7 at the lower end of the crusher, at relatively high speed, thereby causing the head 3 to gyrate at a correspondingly high speed, within and relative to the concave 4. The raw material 44 including lumps of various sizes which are to be reduced, is spouted into the hopper 51 and falls by gravity into the upper vertical portion of the crushing chamber 45, and there is no restriction whatever to the quantity of material thus fed to the crusher. As the admitted material advances by gravity through the successive vertical and outwardly flared portions of the crushing chamber 45, it receives a rapid succession of blows from the gyrating head 3, the speed of gyration of which is such as compared to the throw and to the relative inclination of the crushing surfaces, that all of the material remains free to fall or to slide in contact with one of the members only, under the influence of gravity, during the entire recession period of the head and also during a considerable portion of the period of approach constituting each gyration. Disregarding frictional resistance between the particles of material, and between these particles and one of the crushing members with which they may come in contact, the travel of the material toward the discharge opening, is interrupted only during the impact period, and the particles are never wedged by the influence of gravity between the opposed crushing surfaces. The vibration of the crusher structure as a unit, permitted by the flexible suspension thereof upon cables 17, and caused by the unbalanced masses gyrating about the central crusher axis, also enhances feeding of material through the crushing zone, by retaining the particles of the mass in a state of constant agitation. By thus depending solely upon impact and avoiding subsequent direct crushing by wedging as in the old style slow speed gyratory crusher, production of excess quantities of fines and dust is eliminated, and maximum quantities of pieces of substantially cubical form and of size approximating the minimum width of the discharge opening, are produced and delivered from the discharge chute 52.

In case a piece of abnormally hard material such as a piece of steel or the like, is admitted to the crushing chamber 45, the downward pressure of the head 3 upon the thrust ring element 10 will become so great that the annular plunger 11 is forced downwardly, and if the piece is not too large, displaces sufficient fluid from the chamber 22 to permit the obstruction to pass through the discharge opening without damaging the crusher. When the plunger 11 is thus forced downwardly, the fluid which must escape from the chamber 22, is urged into the conduit 21 from which an equal quantity of fluid is displaced past the check valve 19 into the source 12, the valve 19 being raised from its seating to permit rapid transfer of the fluid into the source 12. By virtue of the increase in fluid content in the source 12, the piston 13 is forced downwardly and compresses the springs 14, and if the downward motion of the piston 13 and block 37 is sufficient the switch 54 will be closed thus sounding the alarm and notifying the attendant to be on guard. If the downward motion of the piston 13 continues, the passage 47 is eventually brought into direct communication with the source 12 and the fluid pressure established within the source 12 is communicated to the auxiliary plungers 48 thereby causing the springs 14 to be quickly additionally compressed. When the obstruction has passed through the discharge opening, the springs 14 again become effective to raise the pistons 13, 48. Due to the additional length of the central piston 13, this piston will enter the pressure source 12 before the auxiliary pistons 48 reach their normal uppermost position. The fluid confined within the passage 47 by entry of the piston 13 into the source 12, is forced by the auxiliary pistons 48 past the bypass valve 20 and back into the source 12. The pressure exerted by the springs 14 is such, that fluid from the source 12 will gradually be urged through the small holes in the valve 19, and normal pressure of fluid within the chamber 22 and passage 21 will eventually be re-established.

If the abnormally hard piece of material is too large to pass through the discharge opening, fluid is displaced from the chamber 22 to the source 12 until the pistons 13, 48 are forced downwardly to a sufficient extent that the contact member 53 also closes the switch 55, whereupon the motor circuit is automatically broken and the motor 18 is stopped before breakage of crusher parts occurs. The obstruction must then be removed through the inlet opening whereupon normal operating conditions are restored and the motor may again be started.

The stop 36 serves to support the plunger 11, ring element 10, head 13 and main shaft 5 before fluid has been admitted to the pressure system, or when the pressure within said system has been entirely released. This stop 36 is so disposed that it will permit maximum dropping of the head 3 relative to the concave 4, before the stop becomes effective at all, and the stop serves to maintain a space beneath the plunger 11 so that fluid may be readily admitted to the lower face of the plunger.

If it becomes desirable to vary the size of the crusher discharge opening, this opening may be readily made smaller by merely actuating the pump 29 and introducing additional fluid under pressure to the source 12, the passage 21, and the chamber 22. In case it becomes desirable to increase the crusher discharge opening, some of the fluid may be withdrawn from the fluid pressure system. When oil is utilized, the fluid thus admitted to and discharged from the pressure system, may be either withdrawn from or returned to the crusher lubricating system. It will be apparent that by thus adjusting the quantity of fluid in the fluid pressure system any desired fixed discharge opening can be established.

When the head 3 is raised or lowered relative to the concave 4, the distance from the fulcrum point 56 to the thrust element 10 changes. Due to the fact that the position of the bearing 16 in the spider 28 is fixed, and that the eccentric 7 is rotatable in a fixed bearing in the lower frame, the position of the fulcrum point 56 cannot change. The spherical surface of the thrust element 10 has a fixed radius, so that when vertical adjustment of the head 3 is made, surface coaction could not be maintained between the head 3 and the spherical surface of the ring element 10, if the ring element were fixed against lateral movement. By permitting the ring element 10 to float upon the plunger 11, however, proper surface coaction is at all times maintained between the upper and lower surfaces of the thrust element 10 and the adjacent structure. If the spider 28 were omitted, the fulcrum point 56 would vary its position in accordance with variations due to vertical adjustment of the head 3, and the spider 28 therefore functions to main-

tain the shaft 5 in proper alinement with the eccentric 7 irrespective of the position of adjustment of the head 3. It will therefore be noted that the freely floating ring element 10 effectively compensates for variations in the length of the radius between the fulcrum point 56 and the spherical thrust surface, while maintaining surface coaction at this thrust surface.

While the crusher is in operation, the centrifugal pump 25 which is detachably secured to the lower extremity of the drive shaft 8, is operating at high speed to withdraw oil from the accumulating chamber 26 and to deliver the oil past the check valve 40 and through the pipe 38 to the purifier 15. In the purifier 15, the oil may be filtered and thus cleared of impurities, after which the clean oil is discharged from the purifier 15 through the pipe 39, by gravity. The oil flows upwardly through a passage 43 formed in the inner wall 45 of the main thrust bearing, and is discharged directly into the upper portion of the recess between the walls 46, 42 within which the thrust ring element 10 is disposed. The excess oil flows over the top of the inner wall 46 and floods the eccentric 7 with lubricant. After serving to lubricate the inner and outer bearing surfaces of the eccentric 7, the oil flows downwardly over the thrust bearing 50 and is eventually discharged into the chamber 26 to be re-circulated by the pump 25. Any oil which succeeds in passing laterally beyond the bearing surfaces of the element 10, is drained back into the system before it can reach the dust seal ring 24. Delivery of oil to the discharged product is thereby avoided, and the dust seal ring 24 cooperating with the apron 23 serves to prevent dust from entering the lubricating system.

From the foregoing description it will be apparent that the thrust bearing located directly beneath the head and above the eccentric 7, is constantly flooded with lubricant and provides an efficient fluid pressure support capable of sustaining the vertical reactions due to normal crushing. The effective position of this support is conveniently adjustable to vary the characteristics of the finished product, and the relief mechanism associated with the fluid support acts quickly and effectively to prevent breakage of parts under abnormal conditions of operation. The dust seal directly beneath the head not only prevents dust from entering the lubricating system, but is also so disposed and constructed that it prevents oil from entering the final product, and the eccentric bearing surfaces are also abundantly supplied with clean oil.

The drive shaft 8 is suspended from the shaft of the motor 18 and is supported in bearings located on opposite sides of the eccentric 7. The pump rotor 25 is accessible by merely removing a bottom plate from the lower cap 41, and the entire pump may be removed by detaching the cap 41. The eccentric thrust bearing 50 is not disturbed by removal of the cap 41, but may be subsequently removed to effect downward removal of the eccentric 7 from the crusher. The driving plate 57 may also be removed without disturbing the thrust bearing 50 or the eccentric 7, upon removal of the keys 33, 49, by slipping the plate downwardly through the central opening of the thrust ring 27.

The improved crusher has proven highly successful in commercial operation under the most severe tests, and produces extremely desirable product and has enormous capacity when operating upon unusually hard material and without any necessity of restricting the feed.

It should be understood that it is not desired to limit the invention to the exact details of construction and to the precise mode of operation herein shown and described, for various modifications within the scope of the claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In a crusher, the combination of a pair of annular crushing members, means for holding said crushing members in spaced apart relation so as to form a crushing chamber, said holding means comprising a frame and bearings therein, means for causing one of said crushing members to gyrate relative to the other of said crushing members to crush material, means for normally supporting said one of said crushing members a predetermined distance from said other of said crushing members, said supporting means comprising a fluid support having an annular plunger encircling said gyrating means, and means operable upon abnormal conditions within said crusher to increase the distance between said crushing members, said last mentioned means comprising an excess fluid pressure relieving mechanism in communication with said fluid support.

2. In a crusher having inner and outer crushing members arranged in spaced relation so as to form a crushing chamber having a discharge opening, the combination of means for gyrating said inner member relative to said outer member to crush material, means for sustaining the weight of said inner member and the normal crushing reaction thereon, said last mentioned means comprising a fluid support located between said moving means and said crushing members, and a fluid pressure relieving mechanism responsive to excessive reaction thrust on said inner member for automatically increasing said discharge opening, and means for adjusting said sustaining means to vary the normal size of said discharge opening.

3. In a gyratory crusher, the combination of a stationary crushing member, a gyratory crushing member, means for holding said gyratory member in spaced apart relation with said stationary member so as to form a crushing chamber having a discharge opening, said holding means comprising bearings and a fluid support, said means also comprising a pressure supply source and a pump communicable with said support for varying the quantity of fluid in said source to adjust said discharge opening, and means for gyrating said gyratory member relative to said stationary member to crush material.

4. In a gyratory crusher, the combination of a stationary crushing member, a gyratory crushing member, means for holding said gyratory member in spaced apart relation with said stationary member so as to form a crushing chamber having a discharge opening, said holding means comprising bearings constituting respectively a fulcrum support and a thrust reaction support, means for adjusting said thrust support to vary the size of said discharge opening, a floating ring element located between said thrust support and said gyratory member and arranged for limited lateral movement relative to said support, and means for gyrating said gyratory member to crush material.

5. In a gyratory crusher, the combination of a stationary crushing member having an axis, a

gyratory crushing member, means for holding said gyratory member in spaced relation with said stationary member to form a crushing chamber having a discharge opening, said holding means comprising bearings constituting respectively a fulcrum point support and a reaction thrust support, means for adjusting said thrust support bearing to vary the size of said discharge opening, a floating ring element having a plane surface slidably carried by said thrust support bearing and arranged for lateral movement relative to said axis and having a spherical surface in sliding engagement with said gyratory member, and means for gyrating said gyratory member about said fulcrum point to crush material.

6. In combination, a pair of annular crushing members so arranged as to form a crushing chamber, a shaft fulcrumed at a fixed point and supporting one of said members for gyration relative to the other about said point, a rotatable member having an eccentric bearing therein journaling said shaft, means for rotating said rotatable member to gyrate said shaft and said gyratory crushing member, and means for sustaining the weight of said shaft and said gyratory crushing member and the crushing reaction thereon, said sustaining means comprising a fluid pressure support arranged concentric of said rotatable eccentric member and having a floating thrust distributing ring in engagement with said gyratory crushing member.

7. In combination, a pair of members cooperating to form a crushing chamber, means for relatively gyrating said members to crush material, means supporting one of said members and disposed to yield upon occurrence of abnormal conditions of operation within said crushing chamber, an alarm disposed to be operated upon predetermined yielding of said supporting means resulting from abnormal conditions of operation to indicate said abnormal conditions, and means connected to subsequently stop said gyrating means upon further yielding of said supporting means resulting from more serious abnormal conditions of operation within said crushing chamber.

8. In a gyratory crusher comprising stationary and gyratory crushing members mounted in a frame, the combination of means for causing said gyratory crusher member to gyrate relative to said stationary crushing member, said means comprising an eccentric journaled in said frame, a member carried by said frame and having a pair of concentric cylindrical wall portions forming an annular recess below said gyratory crushing member, means for supporting said gyratory crushing member, said supporting means comprising an annular piston within said annular recess, a dust seal member carried by said gyratory crusher member and having a cylindrical surface concentric of said gyratory crushing member, and an annular wiping member carried by one of said concentric cylindrical wall portions engaging said cylindrical surface.

9. In a crusher, the combination of a frame, a stationary crushing member mounted in said frame, an eccentric rotatably journaled in said frame, a gyratory crushing member having a shaft journaled in said frame and in said rotatable eccentric, a thrust bearing member mounted on said frame so as to surround said shaft and having a pair of concentric cylindrical walls forming an annular recess, an annular piston movably disposed within said recess and arranged to support said gyratory crushing member, and a body of liquid within the annular recess for supporting said annular piston.

10. In a gyratory crusher having stationary and gyratory crushing members arranged in spaced relation so as to form a crushing chamber having a discharge opening, the combination of a reaction support comprising a confined body of liquid and a plunger member arranged so as to support said gyratory crushing member, and means for varying said discharge opening by varying the quantity of liquid in said body.

11. In a gyratory crusher having a concave, a crusher head mounted on a shaft, a stationary guide bearing and a rotatable eccentric bearing holding said shaft and head within said concave, the combination of a thrust bearing supporting said shaft and head, fluid pressure means for raising and lowering said thrust bearing relative to said stationary guide bearing to adjust the position of said head with respect to said concave, and means responsive to a force on said thrust bearing in excess of a predetermined amount for causing longitudinal movement of said head and shaft.

12. A crushing mechanism comprising relatively fixed and movable crushing members disposed in cooperating crushing relationship, liquid pressure apparatus disposed to support said movable crushing member in predetermined relation to said fixed crushing member, resilient pressure exerting means associated with said liquid pressure apparatus and disposed to yield when the pressure in said liquid pressure apparatus exceeds a predetermined maximum to permit said movable crushing member to move away from said fixed crushing member, means disposed to limit the movement of said resilient means in the direction tending to move said movable crushing member toward said fixed crushing member to position said members in their normal predetermined relation, and means for varying the quantity of liquid in said liquid pressure apparatus to adjust the normal position of said movable crushing member relative to said fixed crushing member.

13. A crusher comprising a fixed crushing member, a cooperating movable crushing member disposed in spaced crushing relationship with said fixed crushing member, a piston disposed to move said movable crushing member relative to said stationary crushing member, a liquid pressure apparatus associated with said piston and having liquid disposed to exert pressure on said piston, a resilient pressure exerting device associated with said liquid pressure apparatus and adapted to yield upon the pressure in said liquid exceeding a predetermined maximum, means for limiting the movement of said resilient pressure exerting device in the direction tending to force said liquid against said piston to limit the movement of said movable crushing member toward said fixed crushing member, and means for varying the volume of liquid in said liquid pressure apparatus to adjust the normal position of said movable crushing member relative to said fixed crushing member.

14. A crusher comprising relatively movable cooperating crushing members disposed in spaced crushing relationship, means for actuating said crushing members to crush material therebetween, a piston associated with one of said crushing members for moving it relative to its cooperating crushing member to adjust the crushing space therebetween, a closed liquid chamber including a cylinder disposed to receive said piston, a liq-

uid filling said chamber, means for varying the quantity of said liquid in said chamber to change the position of said piston in said cylinder and thereby adjust the relative spacing of said cooperating crushing members, resilient pressure responsive means connected to said chamber and adapted to yield and permit rapid displacement of a portion of said liquid upon pressure in excess of a predetermined amount occurring in said liquid as the result of uncrushable material between said crushing members to permit relative displacement of one of said crushing members, means for limiting the rate of return flow of said liquid into said chamber to return said displaced crushing member gradually to its normal position, means limiting the action of said resilient pressure means to prevent it moving said piston beyond its normal adjusted position, and control means responsive to predetermined movement of said piston for sounding an alarm to indicate said abnormal operating conditions and for subsequently stopping the operation of the crusher upon dangerous operating conditions resulting from the presence of said uncrushable material in the crusher.

15. A gyratory crusher comprising a frame carrying a stationary annular crushing element, a movable tapered crushing element disposed within said stationary crushing element in cooperating crushing relation therewith, a shaft disposed to support said movable crushing element in operating position, a bearing carried by said frame above said crushing elements and disposed to engage said shaft and to define a fulcrum point for said movable crushing element, means for gyrating said shaft and said movable crushing element about said fulcrum point, a spherical bearing positioned below said movable crushing element and disposed to support it for gyration about said fulcrum point, means carried by said frame for moving said supporting bearing vertically to adjust the position of said tapered movable crushing element relative to said annular crushing element, and a plane bearing supporting said spherical bearing on said adjusting means to permit lateral movement thereof to compensate for the changes in position of said spherical bearing relative to said fulcrum point resulting from said vertical adjustment thereof.

16. A crusher of the gyratory type, comprising an annular stationary crushing element, a movable crushing element of conical shape disposed within said annular stationary crushing element, means disposed to gyrate said conical crushing element within said stationary crushing element, an annular piston encircling said gyrating means, a universal bearing interposed between said piston and said gyrating conical crushing element to enable said piston to support said crushing element while it is gyrating, a cylinder disposed to engage said piston, a liquid within said cylinder and supporting said piston, and means for varying the quantity of said liquid to adjust the position of said gyrating crushing element relative to said stationary crushing element.

17. A crusher of the gyratory type, comprising an annular stationary crushing element, a movable crushing element of conical shape disposed partly within said annular stationary crushing element, means disposed to gyrate said conical crushing element within said stationary crushing element, an annular piston encircling said gyrating means, a universal bearing interposed between said piston and said gyrating conical crushing element to enable said piston to support said crushing element while it is gyrating, a cylinder disposed to engage said piston, a liquid within said cylinder and supporting said piston, means for varying the quantity of said liquid to adjust the position of said gyrating crushing element relative to said stationary crushing element, a pressure accumulator associated with said cylinder and adjusted to relieve said liquid therein of excessive pressure above a predetermined maximum to permit displacement of said piston and said movable crushing member.

18. A crusher of the gyratory type, comprising an annular stationary crushing element, a movable crushing element of conical shape disposed partly within said annular stationary crushing element, means disposed to gyrate said conical crushing element within said stationary crushing element, an annular piston encircling said gyrating means, a universal bearing interposed between said piston and said gyrating conical crushing element to enable said piston to support said crushing element while it is gyrating, a cylinder disposed to engage said piston, a liquid within said cylinder and supporting said piston, means for varying the quantity of said liquid to adjust the position of said gyrating crushing element relative to said stationary crushing element, a pressure accumulator associated with said cylinder and adjusted to relieve said liquid therein of excessive pressure above a predetermined maximum to permit displacement of said piston and said movable crushing member, and alarm means associated with said accumulator and disposed to sound an alarm upon displacement of said piston a predetermined amount.

19. A crusher of the gyratory type, comprising an annular stationary crushing element, a movable crushing element of conical shape disposed partly within said annular stationary crushing element, means disposed to gyrate said conical crushing element within said stationary crushing element, an annular piston encircling said gyrating means, a universal bearing interposed between said piston and said gyrating conical crushing element to enable said piston to support said crushing element while it is gyrating, a cylinder disposed to engage said piston, a liquid within said cylinder and supporting said piston, means for varying the quantity of said liquid to adjust the position of said gyrating crushing element relative to said stationary crushing element, a pressure accumulator associated with said cylinder and adjusted to relieve said liquid therein of excessive pressure above a predetermined maximum to permit displacement of said piston and said movable crushing member, alarm means associated with said accumulator and disposed to sound an alarm upon displacement of said piston a predetermined amount, and control means associated with said accumulator and connected to stop said gyrating means upon displacement of said piston a further predetermined amount upon the occurrence of dangerous operating conditions within said crusher.

RAY C. NEWHOUSE.