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Davis et al.

[11] **3,797,760**

[45] **Mar. 19, 1974**

[54] **ADJUSTING CRUSHER UNDER LOAD**

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[52] **U.S. Cl.** **241/30**, 241/290

[51] **Int. Cl.** **B02c 2/00**

[58] **Field of Search** 241/27, 30, 286, 290

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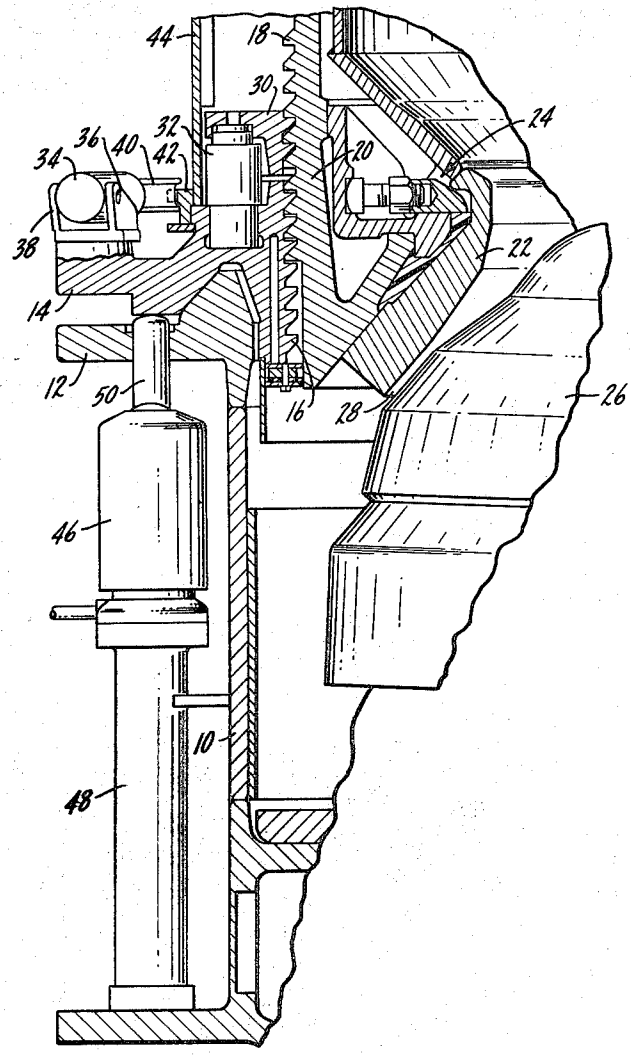
Primary Examiner—Granville Y. Custer, Jr.

Attorney, Agent, or Firm—Howard T. Markey

[57] **ABSTRACT**

This is a cone crusher and method of adjusting it under load by partially unclamping the bowl to an extent such that the bowl may be rotated but with some clamping pressure maintained so that the threads stay in full contact thereby avoiding any damage to the threads from the crushing blows.

21 Claims, 7 Drawing Figures



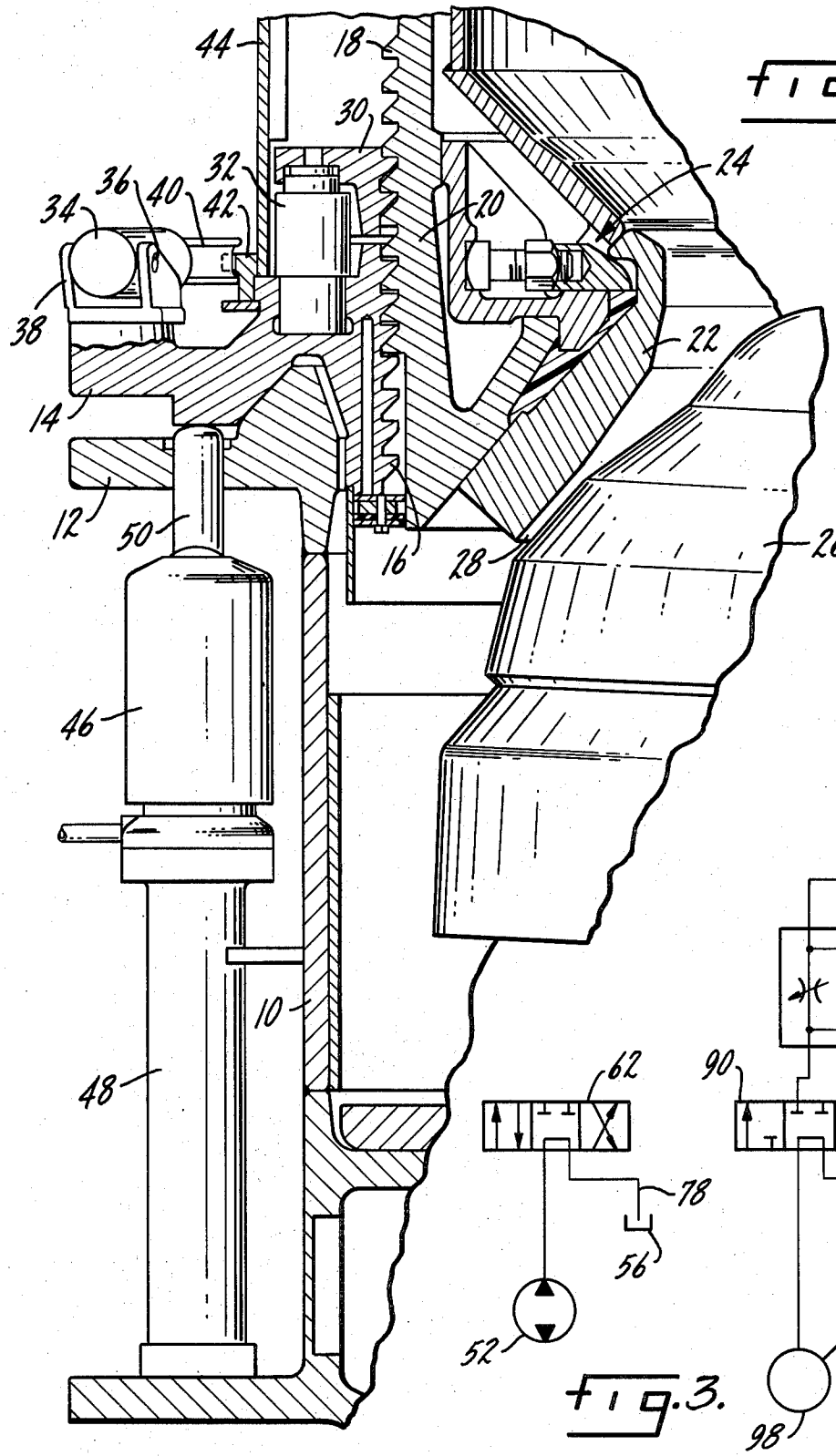
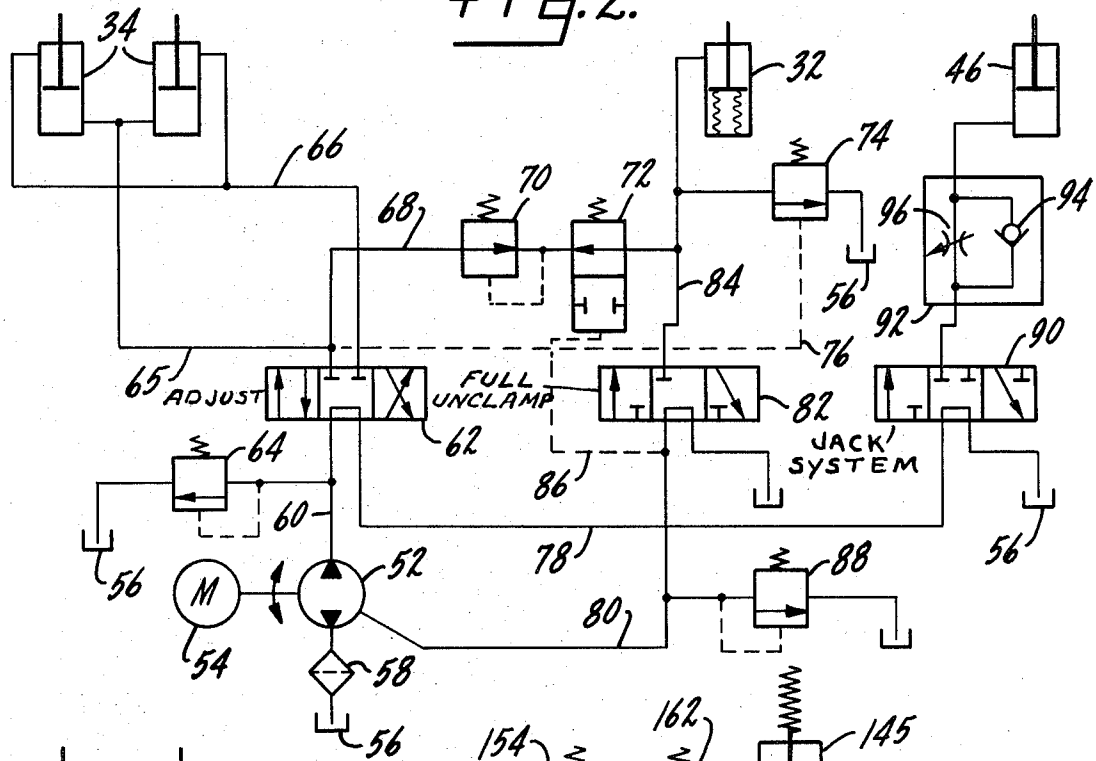

44
18
30
32
36
40
42
34
38
14
12
50
16
28
24
20
22
26
46
10
48

fig.1.

46
92
62
90
78
56
56
52
98

fig.3.

fig. 2.


34
66
68
70
72
32
74
46
96
94
84
56
92
90
76
65
ADJUST
FULL UNCLAMP
82
62
64
JACK SYSTEM
86
60
78
56
M
52
88
80
54
58
56

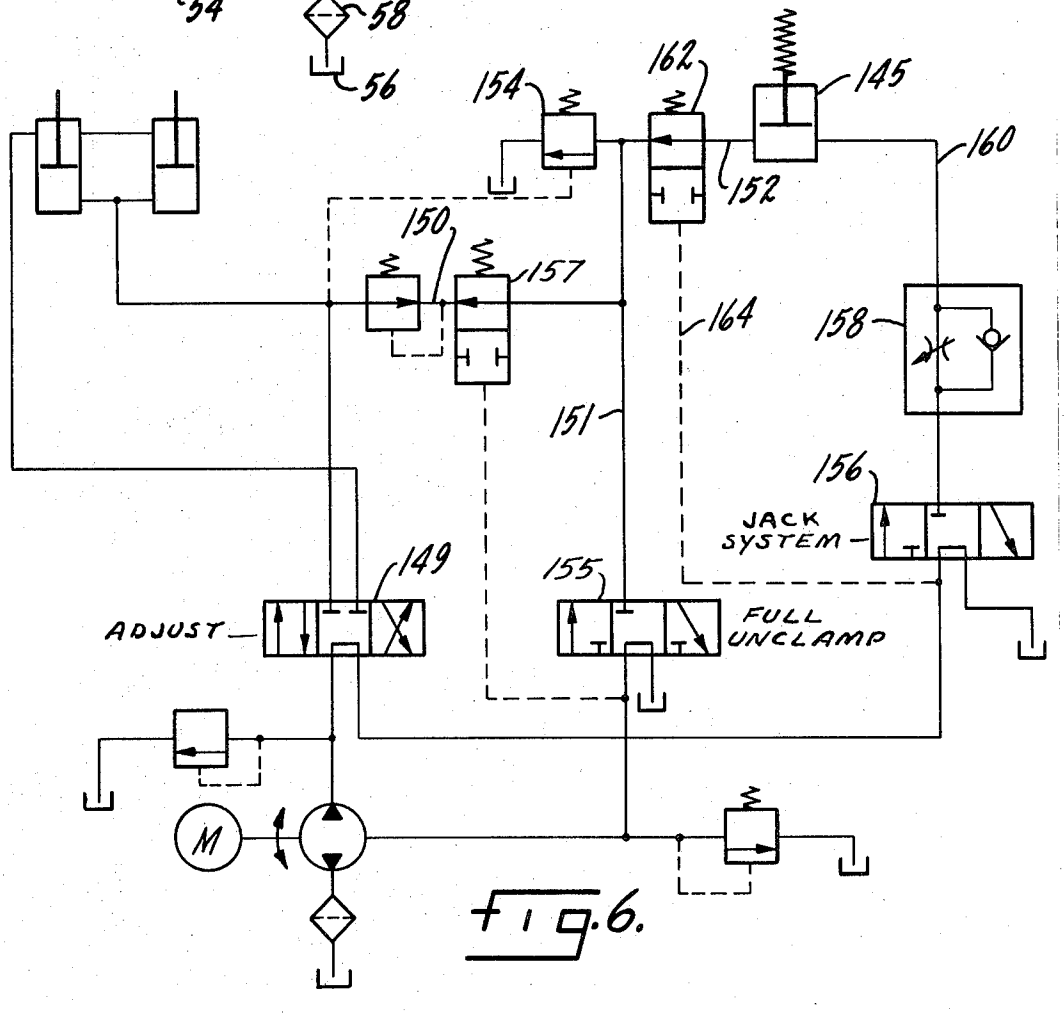

154
162
145
160
152
150
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164
158
151
156
JACK SYSTEM
149
155
ADJUST
FULL UNCLAMP
M

fig. 6.

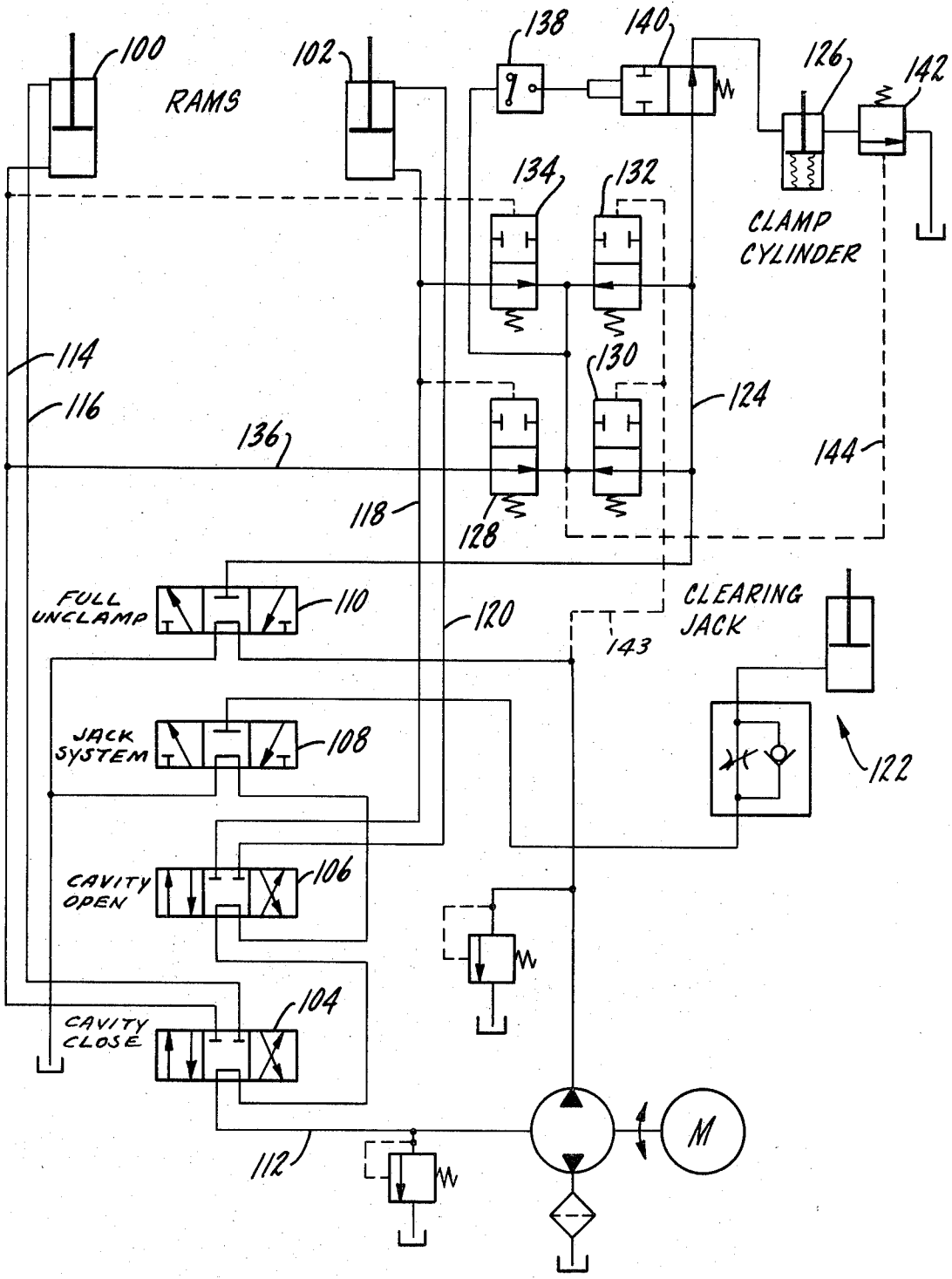

100
RAMS
102
138
140
126
142
CLAMP CYLINDER
134
132
130
124
114
116
136
144
118
128
FULL UNCLAMP
110
120
143
CLEARING JACK
JACK SYSTEM
108
122
CAVITY OPEN
106
CAVITY CLOSE
104
112
M

fig. 4.

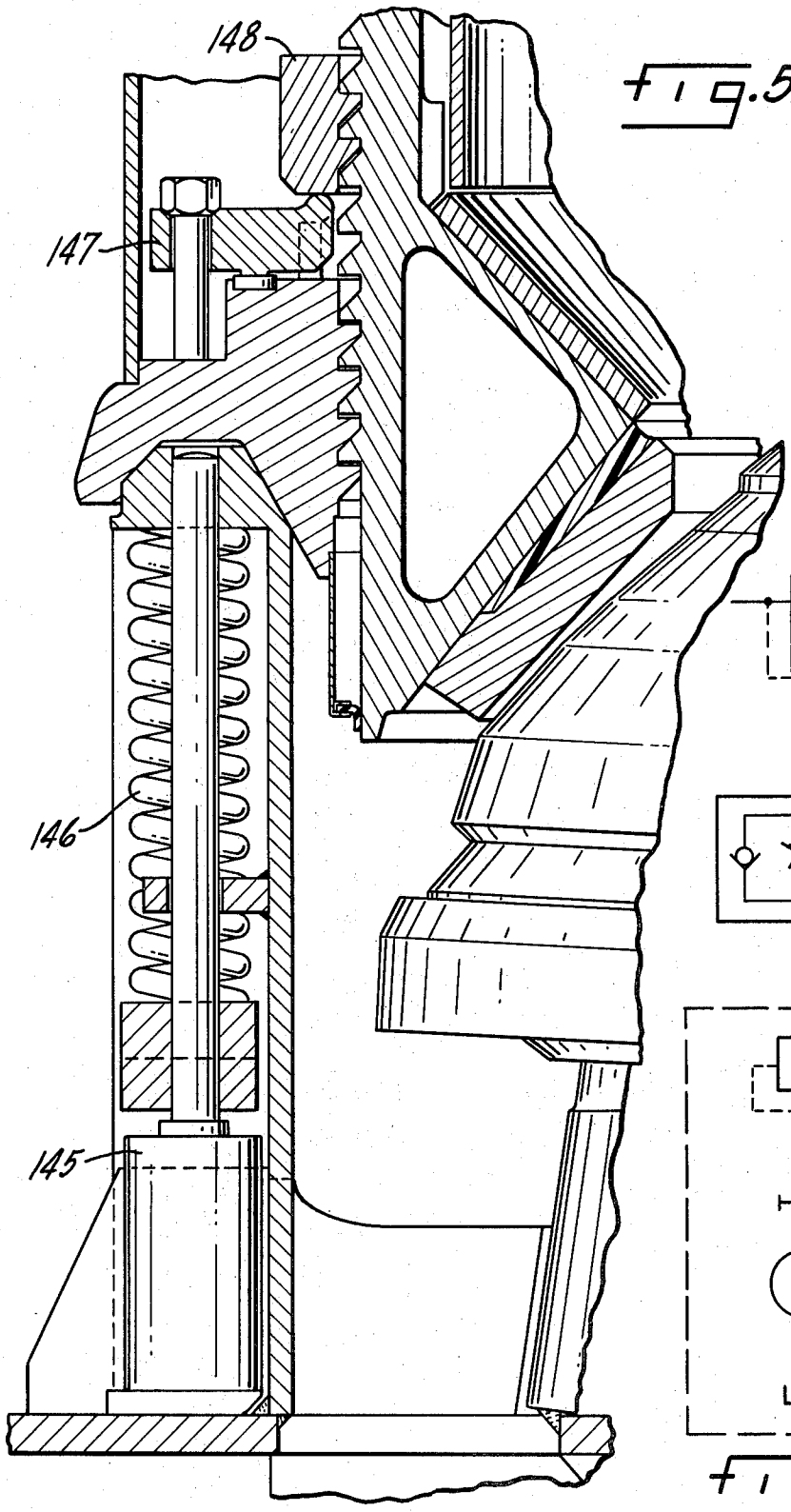


fig.5.

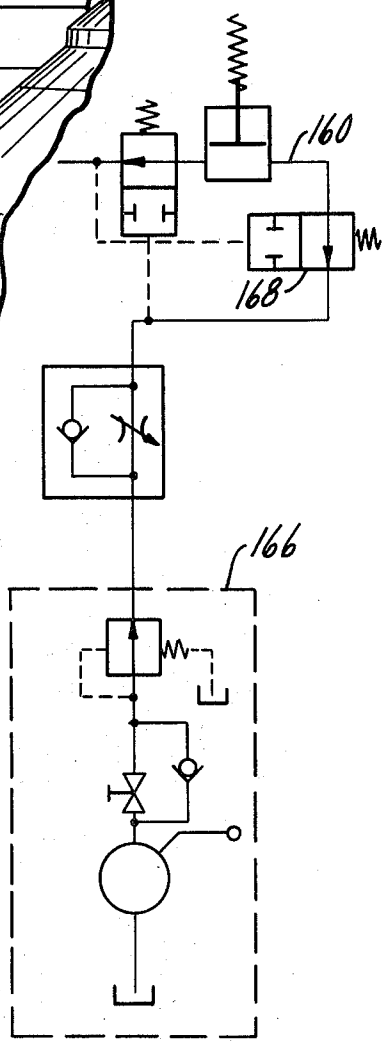


fig.7.

ADJUSTING CRUSHER UNDER LOAD

SUMMARY OF THE INVENTION

This invention is concerned with adjusting a cone crusher under load without damaging the bowl threads.

Crushers for many years have had the bowl screw-threaded into the adjustment ring which is held by a spring or pneumatic release on the main frame. From time to time the bowl needs adjusting, either to change the size of the crushing cavity or to compensate for wear on the bowl liner and mantle. Rotation of the bowl, either one way or the other, will cause it to turn either up or down. When crushing quite hard and abrasive material the bowl may require adjustment quite frequently to compensate for wear, for example once every 8 hours. Adjustment normally requires the crusher to be shut down while the bowl is being rotated to avoid damage to the threads between the bowl and adjustment ring. Shutting down the crusher results in lost production, requires the use of labor and is generally expensive and inefficient.

A primary object of this invention is to adjust a crusher under load, meaning while material is going through it and being crushed, so that it doesn't have to be shut down.

Another object is a method of adjusting a crusher under load that avoids any damage to the bowl threads.

Another object is a method of adjusting a crusher under load where the bowl is rotated by a hydraulic ram which involves the partial unclamp at the beginning of ram excursion and an automatic full reclamp of the bowl at the end of ram excursion.

Another object is a system of the above type applicable to a so-called pressure-off clamping system.

Another object is a system of the above type usable with dual rams or rams in pairs so that the bowl may be rotated in either direction automatically.

Another object is a system of the above type which requires no modification in the structure of the crusher itself and only minor piping changes in the crusher's hydraulic system.

Another object is a system of the above type which may be applied to either new machines or conversion of machines in the field at a minimum of expense.

Another object is a system of the above type that requires a minimum of maintenance.

Other objects will appear from time to time in the ensuing specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view, partly in section, of a conventional cone crusher;

FIG. 2 is a schematic of a hydraulic circuit usable with the FIG. 1 apparatus;

FIG. 3 is a variation of FIG. 2;

FIG. 4 is another circuit for a so-called double ram system;

FIG. 5 is a side view, partly in section, of a variant form of crusher;

FIG. 6 is a schematic for a so-called rocker arm bowl clamping system; and

FIG. 7 is a variation of FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 a portion of a conventional crusher is shown and includes a generally circumferential main frame 10 having an outstanding flange 12 at or near its upper end supporting an adjustment ring 14 which is provided with screw threads 16 on its inner surface that match and mesh with corresponding screw threads 18 on the outer periphery of a bowl 20. The bowl supports an upper wearing element known as a bowl liner 22 with any suitable holding or releasing mechanism 24 so that when the liner is worn out, it may be removed and replaced. The bowl and bowl liner overhang and oppose a crushing head 26 which is mounted for gyration in the main frame, all of which is conventional. The head defines a crushing gap or cavity 28 with the bowl liner through which the material passes and receives crushing nips in a conventional manner.

An internally-threaded clamping ring 30 is screw-threaded to the bowl above the tilting or adjustment ring with a plurality of clamping units 32 between them. All of the clamping units, as a group, provide an upthrust to the clamping ring which in turn tends to lift the bowl. This functions to eliminate what is known in the trade as thread clearance, which means that the top inclined flank of the bowl threads will be in contact with and under pressure against the bottom inclined flank of the threads on the adjustment ring. Any clearance in the threads will be between the bottom horizontal flank of the bowl threads and the top horizontal flank of the tilting ring threads. Thus, the upthrust of the clamp units 32, through the clamping ring 30, not only will lift and clamp the bowl in the tilting ring tending to prevent it from rotating but also will put the thread clearance, so to speak, on the bottom of the bowl threads so that as the crushing blows are applied upwardly by the head against the bowl, the bowl itself will not vibrate in the adjustment ring.

In the arrangement shown in FIG. 1 the clamp units 32 are of the type that use springs, for example a stack of so-called Belleville springs or cone washers which apply an upthrust so the clamp ring 30 with an internal hydraulic piston and cylinder arrangement for compressing the springs to thereby release or eliminate the upthrust allowing the bowl 20 to drop down through the thread clearance. This, in effect, unclamps the bowl so that it may be rotated. This particular type of clamp cylinder arrangement is well-known and is shown and described in U.S. Pat. No. 3,140,835, issued July 14, 1964.

With the bowl unclamped or unlocked, one or more hydraulic rams 34 are constructed to rotate the bowl. Such a ram may take the form of a hydraulic cylinder pivoted as at 36 in a yoke 38 which in turn is pivoted about a vertical axis on the tilting or adjustment ring 14. A piston extends from the cylinder and is formed into a nose 40 which engages ribs or a notched ring 42 on the top cap 44 which in turn is connected or keyed to the bowl so that when the top cap is rotated by the ram, the bowl will also rotate, all of which is known.

On occasion the crusher may become plugged or stuck, for example when uncrushable material, such as tramp iron or large pieces of wood, become stuck in the crushing cavity. It is known to provide a plurality of hydraulic jacks 46 disposed about the crusher and mounted in a suitable manner, for example on pedes-

tals 48 if desired so that when the jacks are energized as a group they will provide an upthrust to the tilting ring, possibly through push rods 50, to physically raise the bowl while compressing the spring release, not shown, so that the crushing cavity may be unplugged.

All of the above is intended to illustrate a conventional cone crusher and to lay background for the method, controls and circuits described hereinafter.

As shown and described in U.S. Pat. No. 3,140,835, it is known to release all of the clamping upthrust on the bowl so that it is free to rotate. But the crusher must be stopped first so that crushing blows will not be applied to a loose bowl. In the present arrangement, only a part but not all of the upthrust is released with a partial upthrust remaining so that thread clearance is not eliminated. This is to say that a certain amount of the upthrust is first relieved, a sufficient amount so that the bowl may be rotated. But sufficient upthrust remains to overcome the weight of the bowl and its appurtenances so that thread clearance is still eliminated. The clearance in the threads will still be in the bottom of the threads, which is the same as during full clamping rather than in the top, which is the condition during complete unclamping. This can be accomplished in a number of ways and in a number of varying clamping systems.

In FIG. 2 a hydraulic circuit is shown in which a pump 52 of any suitable design may be driven by a motor 54 that draws hydraulic oil from a sump 56 through a filter 58 and discharged it under pressure through a supply line 60 to a directional control valve 62. The supply line 60 may be connected to a conventional overload release valve 64 which will return oil to the sump at a predetermined overload relief pressure.

The bowl rotating rams, as in FIG. 1, are indicated at 34, two being shown, each double acting and, for purposes of description and illustration, it may be assumed that the rams are 180° apart on opposite sides of the bowl and may be directed so that they rotate the bowl in the same direction, either clockwise or counterclockwise when viewed from above. A line 65 to control valve 62 will cause the rams to extend while a line 66 will cause them to retract. A separate line 68 is connected to line 65 so that at the same time that the rams are extending, thereby rotating the bowl, oil will be supplied to the clamp cylinders 32, only one of which is shown in FIG. 2, so that they act in unison. It will be understood that there are a plurality of clamp cylinders, say 6 or 8, connected in series. Line 68 supplies fluid to the clamp cylinders 32 through a pressure reducing valve 70, and a normally open pilot valve 72. A pilot-operated relief valve 74 is connected to the line to the clamp cylinders which, when it is operated by the pilot line 76, returns the oil to the sump 56.

A partial unclamp takes place as follows. Control valve 62 is shifted to the right so that pressure fluid is applied through line 65 to the rams 34 causing them to extend. At the same time, fluid also goes through line 68 and the pressure reducing valve 70 and pilot valve 72, both of which are normally open, to the clamp cylinders 32. Pressure reducing valve 70 is set so that at a certain pressure it closes. And that pressure is selected at the level necessary to partially unclamp the cylinders 32. Thus the build-up of pressure initially in line 65 and 68 partially unclamps cylinders 32 at which point the pressure reducing valve 70 closes so that the pressure thereafter extends the rams 34 to rotate the bowl. At the end of ram stroke, the pressure in line 65 rises and, at a certain pressure, opens pilot relief valve 74 allowing the springs in the clamp cylinders 32 to reclamp the bowl. The effect of this is that at the conclusion of ram stroke the bowl is immediately fully clamped again.

Control valve 62 could then be shifted to the left which will pressurize the retraction line 66 and vent line 65 to the sump through line 78 causing the rams to retract. Pressure reducing valve 70 opens which vents the clamp cylinders at the same time that pilot relief valve 74 is closing.

The above may be referred to as partial unclamp. On occasion it is desirable to fully unclamp the bowl, for example when the mantle and liner are sufficiently worn and need replacing. To rotate the bowl back out by use of the rams 34 would be far too slow and it is customary to wrap a cable around the bowl and rotate it rapidly by pulling the cable with an overhead crane or a tractor or the like. There are other circumstances where it may be desired to fully unclamp the bowl and rotate it rapidly, either up or down. In any event, this may be accomplished by a line 80 connected to the pump 52 which is controlled by a second directional control valve 82. With the first directional control valve 62 in neutral, the second valve 82 may be operated to supply fluid through a line 84 to the clamp cylinders 32. This will also pressurize the pilot 86 causing the pilot valve 72 to close so that oil will not flow back into the ram and partially extend them. Pilot relief valve 74 will remain closed since its pilot line 76 will not be under pressure. Line 80 leading to the second directional control valve 82 may have an overload relief valve 88.

A jack circuit is also provided which includes line 78 leading to a third directional control valve 90 which supplies pressure fluid through a variable restriction 92 to the jacks 46, only one of which is shown in FIG. 2. It will be understood that a plurality of jacks may be positioned about the crusher connected in series. With control valves 62 and 82 in neutral, valve 90 may be operated to supply pressure fluid through check valve 94 to the jacks 46 thereby raising the bowl and adjustment ring assembly and compressing the spring release so that the cavity may be cleared. Reversal of valve 90 will vent the jacks 46 to the sump. Since the jacks will be under tremendous spring force to prevent the bowl and adjustment ring from slamming down on the frame oil is allowed to return through a variable throttling orifice 96 which controls the speed of descent.

In certain installations that jacks 46 may be used quite infrequently, say a couple times a year while the crusher may be adjusted several times a day. The jacks require tremendous pressures since they have to compress the spring release. So the piping and pump to do this must be correspondingly substantial, far more than that needed by the bowl clamping and adjusting mechanism. So in FIG. 3 a separate arrangement has been shown as a modification of FIG. 2 in which the jacks 46 are operated, say, by a hand pump 98 through the selector valve 90 and throttling orifice valve 92. In this case the main pump 52 could be much smaller and its directional control valve 62 is shown in FIG. 3 with line 78 leading directly to the sump 56. Thus the jacking circuit could be quite substantial while the adjusting

circuit could be made up of smaller and less expensive components.

The invention has been illustrated in FIG. 1 as applicable to a pressure-off bowl clamping system in which the clamp ring is internally threaded and mounted on the outside of the bowl. But this might be reserved, for example the clamp ring could be externally threaded and mounted on the upper portion of the tilting or adjusting ring, such as shown in U.S. Pat. No. 3,397,846, issued Aug. 20, 1968. Other means for affording high pressure to the jacks could be through the use of a less substantial pump in circuit with a booster or pressure amplifier.

The general type of ram arrangement for rotating the bowl has been referred to hereinabove generally as the type shown in U.S. Pat. No. 3,009,660, issued Nov. 21, 1961 and also U.S. Pat. No. 3,325,108, issued June 13, 1967. The ram rotating arrangemen for the bowl could as well be of the type shown in U.S. Pat. No. 3,396,915, issued Aug. 13, 1968.

A single ram, one on each side of the bowl, approximately 180° apart has been referred to as the bowl rotating arrangement. But dual rams might be used so that the bowl could be rotated either up or down without separate adjustment of the rams to reverse their direction of thrust. Double or dual rams normally include four rams, in pairs of two each, on opposite sides of the bowl about 180° apart, such as shown in U.S. Pat. No. 3,570,774 issued Mar. 16, 1971 and U.S. Pat. No. 3,396,915, issued Aug. 13, 1968. An arrangement for dual rams has been shown in FIG. 4. One ram 100 is disposed to rotate the bowl in one direction, say, down, and the other 102 to rotate it in the other direction, say, up. There might be two rams for each direction and paired on opposite sides of the bowl, such as in U.S. Pat. No. 3,570,774. Since a good bit of what is shown in the FIG. 2 circuit is duplicated in FIG. 4, all of the parts will not be renumbered. A series of directional control valves 104, 106, 108, and 110 are shown which are connected to the pump by a supply line 112. Control valve 104 operates the cavity closing ram or rams 100 by lines 114 and 116 while valve 106 operates the cavity opening ram or rams 102 by lines 118 and 120. Directional control valve 108 operates the clearing jack system 122, if it is included like in FIG. 2 and not separate like in FIG. 3. And control valve 110 provides for a full unclamp through line 124 to the clamp cylinders 126. Four pilot operated normally open valves 128, 130, 132, and 134 are provided to isolate one ram system from the other and to prevent oil from backing up into both ram circuits when a full unclamp is applied by directional control valve 110.

Assume that the product is oversize indicating excessive wear of the mantle and liner and the cavity is to be closed by rotating the bowl down. The ram 100 will be energized by operating control valve 104. This will first close pilot valve 134 thereby blocking out or isolating the bowl opening ram 102. It also pressurizes line 136, through valves 128 and 130, through line 124 to the clamp cylinders 126 to partially unclamp. At a predetermined pressure, as read by pressure switch 138 solenoid-operated valve 140 will close thereby holding the clamp cylinders 126 in their partial unclamped position and rams 100 will proceed to rotate the bowl down. When ram 100 reaches the end of a stroke 17 the pressure buildup in line 136 will open pilot valve 142 through pilot line 144 so that the clamp cylinders 126 will be relieved to tank thereby reapplying full clamping pressure to the bowl.

If the bowl is to be rotated up, ram or rams 102 are energized by directional control valve 106 with pilot valve 128 first closing due to the pressure buildup in line 118 to isolate ram system 100 followed by partial unclamping of the clamp cylinders 126 due to a pressure buildup through valves 134 and 132. At a predetermined pressure switch 138 will close valve 140 thereby holding the partial unclamp pressure and causing ram 102 to extend which, when it gets to the end of its stroke causing pressure buildup in pilot line 144, will open valve 142. The clamp cylinders automatically reapply full clamping pressure to the bowl.

When full unclamp of the bowl is desired, directional control valve 110 is operated with pilot valve 130 and 132 initially closing due to pilot line 143 to isolate both ram systems and rendering the unloading valve 142 ineffective. As before, valve 108 may control the jacking system 122 or it may be separate.

The arrangement shown in FIGS. 2 and 3 has been specifically related to a so-called pressure-off clamping system, such as in U.S. Pat. No. 3,140,835. And it is equally applicable to another type of pressure-off clamping system, such as shown in U.S. Pat. No. 3,162,387, issued Dec. 22, 1964 and U.S. Pat. No. 3,009,660, issued Nov. 21, 1961 where the bowl is spring-biased up by a rocker arm system.

In FIGS. 5 and 6 such a variant form has been shown. This is similar in many respects to the FIG. 1 form and FIG. 2 circuit. Since the rams, the directional control valves for the rams, the pump, etc. may be the same, they have not necessarily been renumbered in FIG. 5. In this case the same hydraulic jacks are used to compress the springs that releasably clamp the bowl and also to raise the bowl and compress the spring release when the cavity is to be cleared. Such jacks perform a three-step excursion, the first step to unclamp the bowl for adjustment under load, the second to umclamp the bowl for rapid removal, and the third to raise the bowl for clearance. Such a jack is indicated at 145 in FIGS. 5 and 6. As shown in FIG. 5 the jack opposes a rod and spring 146 which pull down on a rocker arm 147, the inner end of which lifts up on the lock ring 148. A plurality of jacks would be positioned about the crusher, each associated with a rocker arm. Control valve 149 supplies oil to line 150, line 151, to line 152 and the jacks 145. This causes the jacks 145 to apply a partial unclamp. At the end of ram excursion, pilot operated valve 154 opens to release pressure in jack 145 thereby applying full clamping pressure at the end of each ram stroke. For a full unclamp to allow for rapid rotation of the bowl, control 155 supplies oil through line 151 to the jacks 45 which pilot valve 157 preventing a reverse flow through line 150. For clearance, directional control valve 156 is operated to supply pressure fluid through the throttling control 158 to the jacks through line 160. Pilot valve 162, which is normally open in line 152, closes that line to prevent oil from running out that side when the pressure through its pilot line 164 operates it. When the jacks 145 lower and the bowl comes back down under the tremendous force of the spring release, valve 162 stays closed until all of the oil has passed through the throttling valve in 158.

As before, the jack system can be separated from the clamping and unclamping system and this variation is shown in FIG. 7 in which a hand pump 166 supplies

pressure fluid to the jacking connection **160.** When pressure fluid is being supplied to the jack for a partial unclamp, a pilot operated valve **168** is positioned in line **160** to prevent the oil from running out the other line of the jack to the hand pump.

The particular hand or direction of the threads between the bowl and adjustment ring relative to the direction of rotation of the head and the crushing reaction that occurs therefrom may well affect the thrust necessary to adjust the crusher. For example, with threads of a particular hand, depending upon the direction of rotation of the head the crushing force or reaction may tend to turn the bowl up or down. It may well be that a different partial clamping thrust may be necessary or desirable, depending upon whether the thrust reaction is causing the bowl to tend to turn with or against the direction of rotation designed.

We claim:

1. A method of adjusting the size of the crushing cavity in a cone crusher while the crusher is in operation, the crusher having a generally circumferential main frame with a bowl mounted for adjustment in the main frame opposite a crushing head mounted for gyration within the main frame and bowl clamping means for applying a clamping thrust to the bowl to clamp it in the main frame; including the steps of applying a full clamping thrust to the bowl during normal crushing operation, partially relieving the clamping thrust when the bowl is to be adjusted to an extent such that the bowl may be adjusted but sufficient clamping thrust will be mainained so that the bowl will be in firm contact with the frame, moving the bowl through the desired amount of adjustment while maintaining such partial clamping thrust during bowl movement and, at the conclusion of such bowl adjustment, re-applying the full bowl clamping thrust.

2. The method of claim **1** further characterized in that the bowl is screw-threaded for adjustment in the main frame and the bowl clamping means applies a clamping upthrust to the bowl and in that the bowl is adjusted by rotating it.

3. The method of claim **2** in which the crusher is provided with power means for rotating the bowl, and further including the step of automatically re-applying the full bowl clamping upthrust at the end of each operation of the power means.

4. The method of claim **2** in which the crusher is provided with a hydraulic ram for rotating the bowl in the main frame, and further including the step of automatically reapplying the full bowl clamping upthrust at the end of bowl rotation responsive to the ram reaching the end of its stroke.

5. An apparatus for adjusting the size of the crushing cavity in a cone crusher while the crusher is in operation in which the crusher has a generally circumferential main frame with a bowl mounted for adjustment in the main frame opposite a crushing head mounted for gyration within the main frame and a bowl clamping means for applying a clamping thrust to the bowl to clamp it in the main frame, including means for applying a full clamping thrust to the bowl during normal operation of the crusher, means for partially relieving the clamping thrust when the bowl is to be adjusted to an extent such that the bowl may be moved but sufficient clamping thrust will be maintained so that the bowl will be in firm contact with the frame, and means for reapplying the full bowl clamping thrust at the conclusion of bowl adjustment.

6. The structure of claim **5** further characterized in that the bowl is screw-threaded in the frame and the bowl clamping means applies an upthrust to the bowl to clamp it in the threads in the main frame, the bowl being rotated to adjust it.

7. The structure of claim **6** further characterized by and including power means on the crusher for rotating the bowl, and means for automatically applying full bowl clamping upthrust at the conclusion of each excursion of the power means.

8. The structure of claim **6** further characterized by and including rams on the crusher for rotating the bowl, at least one ram for rotating the bowl in each direction, a hydaulic circuit for operating the rams and bowl clamping means, and means for isolating one ram while the other is rotating the bowl.

9. The structure of claim **6** further characterized in that the crusher is provided with a hydaulic ram for rotating the bowl, a hydraulic circuit for operating the ram and bowl clamping means, means for fully unclamping the bowl clamping means, and means responsive to the full unclamping means for isolating the ram from the hydraulic circuit.

10. In a cone crusher, a generally circumferential main frame, a bowl mounted for adjustment in the main frame and disposed opposite a crushing head mounted for gyration within the main frame, and a bowl clamping system for clamping the bowl in the main frame, including means for applying a full clamping thrust to the bowl during normal operation of the crusher, and means for partially relieving said clamping thrust so that the bowl may be adjusted during operation while still firmly supported on the frame.

11. The structure of claim **10** further characterized in that the bowl is screw-threaded for adjustment in the main frame and the clamping system includes means for applying a releasable upthrust to the bowl to clamp it in its various positions of adjustment so that thread clearance will be removed between the bowl and main frame.

12. The structure of claim **11** further characterized by and including a hydraulic ram on the frame for rotating the bowl, a hydraulic circuit connected to the ram and to the bowl clamping means and constructed so that, when the bowl clamping means is applying a partial clamping pressure, the ram will be operated to rotate the bowl and, when the ram reaches the end of its extension, the bowl clamping means will automatically apply full clamping pressure.

13. The structure of claim **12** further characterized by and including means for releasing the full clamping pressure of the bowl clamping means, and means for isolating the hydraulic ram when the bowl clamping means is fully unclamped.

14. The structure of claim **12** further characterized by and including at least two hydraulic rams, one disposed to rotate the bowl in one direction and the other disposed to rotate the bowl in the other direction, means for selectively energizing either one ram or the other, and means for isolating one ram when the other is operated.

15. The structure of claim **5** further characterized by and including a ram for rotating the bowl, means for applying hydraulic pressure simultaneously to the ram and bowl clamping means so that the ram will rotate

the bowl automatically when the clamping pressure is relieved a sufficient amount to allow the bowl to rotate, and means for automatically relieving the hydraulic pressure to the clamping means responsive to the buildup in pressure when the ram reaches the end of its stroke so that a full clamping thrust will be automatically reapplied to the bowl.

16. The structure of claim **5** further characterized in that the bowl clamping means includes a plurality of springs disposed about the crusher to apply a clamping thrust to the bowl, and the means for relieving the clamping thrust includes a hydraulic circuit with at least one hydraulic cylinder for compressing the springs to release the bowl so it may be adjusted.

17. The structure of claim **5** further characterized by and including a spring release for allowing the bowl to release for tramp iron clearance, and a hydraulic jack circuit for compressing and overcoming the spring release separate from the bowl-clamping means.

18. The structure of claim **8** further characterized by and including means for fully unclamping the bowl-clamping means, and means responsive to the full unclamping means for isolating both rams.

19. The structure of claim **5** further characterized in that the crusher is provided with a spring release for allowing the bowl to release for tramp iron clearance, a series of hydraulic jacks about the crusher with a hydraulic circuit connected thereto constructed and arranged so that upon a first excursion of the jacks, the bowl will be partially released for adjustment, upon a second excursion of the jacks the bowl will be fully released for rapid adjustment of the bowl, and upon a third excursion of the jacks the spring release will be overcome and the bowl raised for tramp iron clearance.

20. The structure of claim **19** further characterized in that the hydraulic circuit includes two components, the first component being arranged to operate the jacks through their first and second excursions, and the second component being arranged to operate the jacks through their third excursion with a tie between the two components so that when the second component is operating the jacks, the first component will be isolated.

21. A method of adjusting a crusher while it is in operation including the steps of applying a full clamping thrust to the bowl during normal crushing operation, partially but not fully relieving the clamping thrust when the bowl is to be adjusted with sufficient clamping thrust remaining so that the bowl is fully and firmly supported in the crusher, and moving material through the crusher while operating the machine with the bowl under the partial clamping thrust.

* * * * *