Feb. 21, 1967 P. M. E. BARROT ETAL 3,305,181

GYRATORY CRUSHERS

Filed Nov. 18, 1963 3 Sheets-Sheet 1

Fig. 1

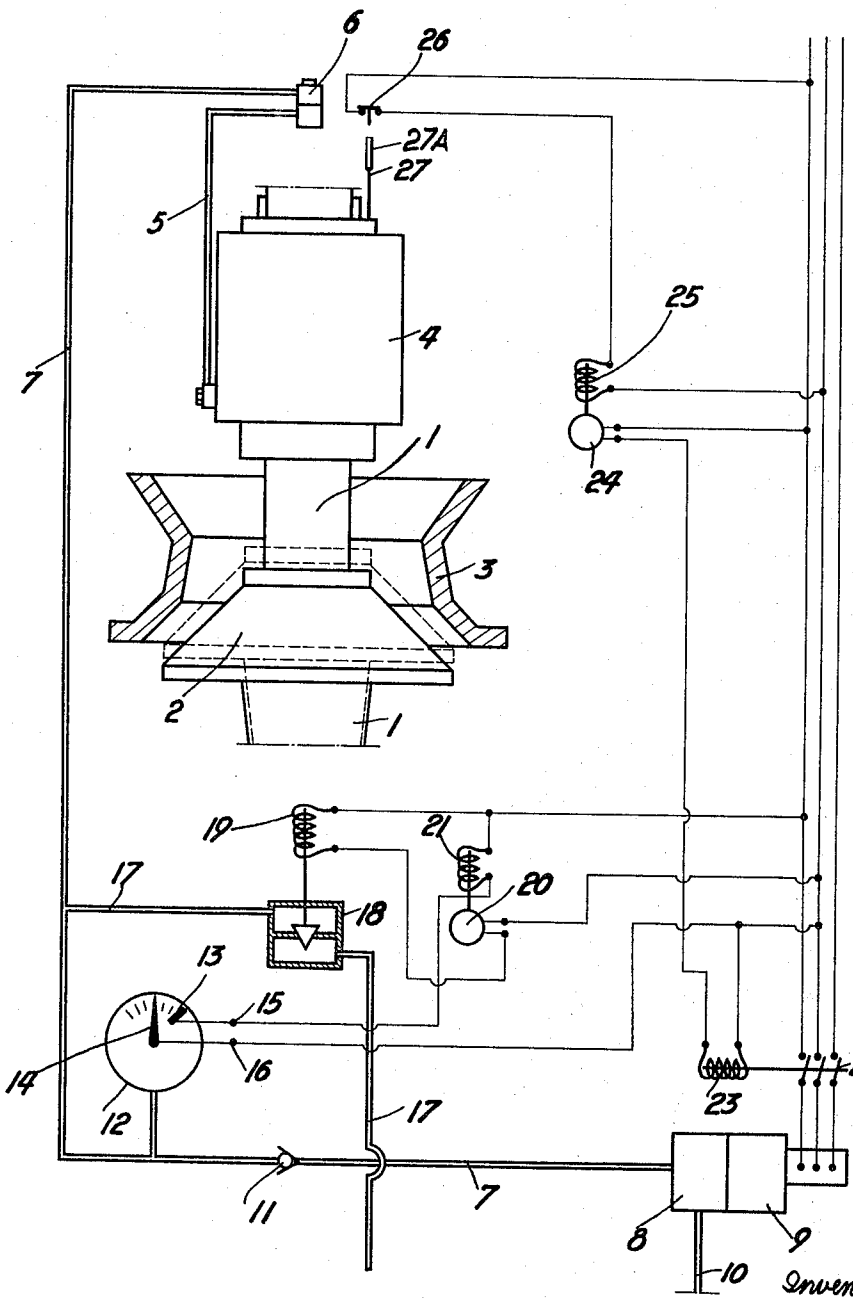

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Fig. 2

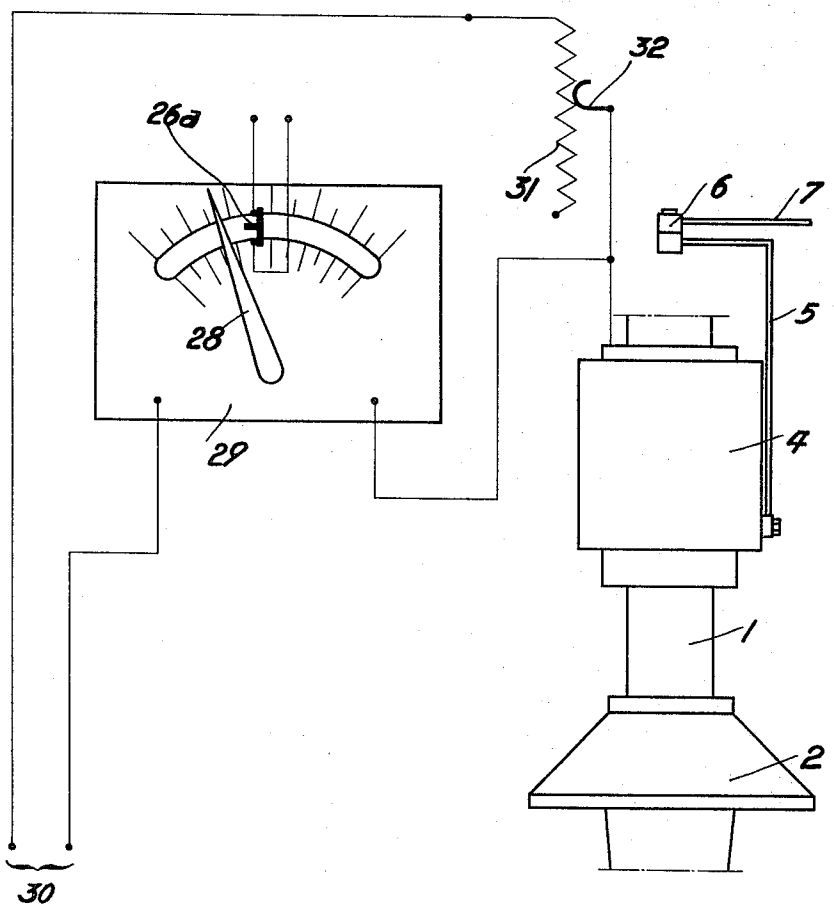

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Fig. 3

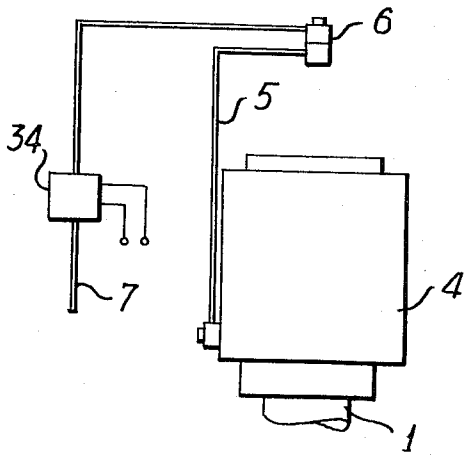


Fig. 4

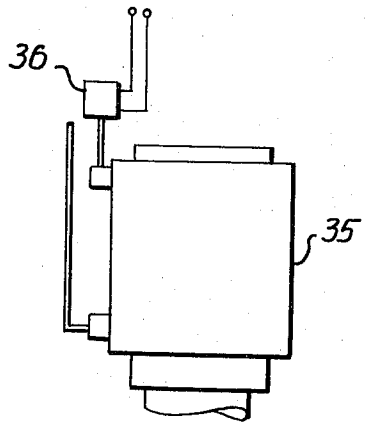


Fig. 5

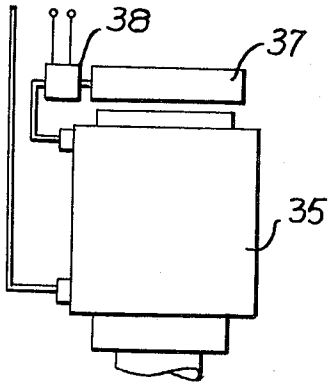
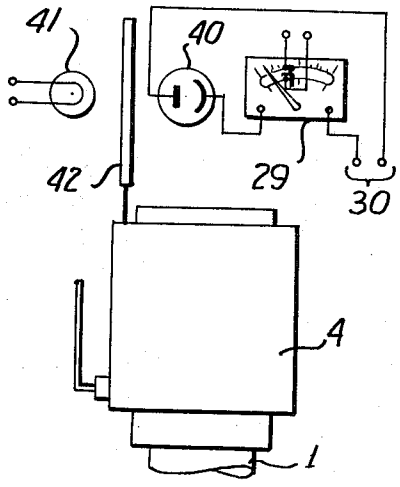


Fig. 6



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GYRATORY CRUSHERS

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9 Claims. (Cl. 241—37)

The present invention relates to gyratory crushers, and more particularly to an improved hydraulic suspension arrangement for the shaft of such crushers, adapted to protect said crushers against accidental overloads.

Gyratory crushers are apparatus which enable a constant and rigorous control of the maximum size of the crushed material to be obtained, but this only in the case where the relative position of the crushing members remains unchanged for a given adjustment. However it often happens that certain crush-resisting objects, such as metal scraps or the like are mixed with the material which is to be crushed, and the passing of such objects between the crushing members results in sudden overloads which are liable to cause serious damage to the various parts of the machine. The same holds true in case of cramming, the causes of which are well known and will not be further described herein.

In order to prevent the occurrence of such accidents, it has already been proposed, in gyratory crushers the shaft of the crushing cone or crushing ring whereof is suspended by means of one or more hydraulic jacks, to provide means imparting a certain resiliency to said suspension, such as hydro-pneumatic accumulators, which are adapted to vary the free cross-section of the crushing opening. While, however, the results achieved may seem spectacular in that the uncrushed pieces succeed in passing through the crusher, the stresses to which the mechanical parts of the apparatus are then subjected, more particularly due to the violent vibrations resulting from the forces exerted thereon, are in no way abolished for that matter.

Now, it has been found that the drawbacks of the above mentioned prior apparatus may be avoided if, as soon as such crush-resisting pieces engage between the crushing members, a relative shifting of said members is automatically caused to take place, so as to achieve the maximum possible spacing therebetween, and if said spacing is thereafter maintained, during a period of time which is at least sufficient for the passing of said parts, and said crusher parts are finally automatically reset in their operating relative position.

An object of the invention is to provide a control device for the suspension means of hydraulically suspended gyratory crushers, by means of which the cone-carrying shaft of said crushers can be automatically lowered and raised again into crushing position in the above mentioned conditions.

Other objects of the invention will be apparent from the foregoing specification.

The device according to the invention essentially comprises means responsive to the pressure of the hydraulic fluid driven by the piston of the suspending hydraulic jack and arranged to control the opening of a discharge valve for said fluid when said pressure reaches a predetermined value, means for maintaining said valve in opened position during a predetermined interval of time, independent from said pressure, means for feeding the hydraulic fluid under the jack piston, means for initiating said feeding action after a predetermined period of time from the opening of said valve, and means to stop said feeding action as soon as the crusher cone has returned to its predetermined operating position.

The invention will be best understood from the following description and appended drawings, illustrating embodiments of said device and the method of operation thereof, and wherein:

FIG. 1 is a diagram of the electric and hydraulic connections in one embodiment of a device according to the invention;

FIGS. 2–6 are diagrammatic views of alternative embodiments of the means for stopping the feeding of the hydraulic fluid into the jack, at the end of the resetting in position of the crusher cone.

In the embodiment illustrated in FIGURE 1, shaft **1** of the gyratory crusher, which supports the crusher cone **2** cooperating with the crusher ring **3** is integral with the piston of a hydraulic jack **4** the body of which is supported so as to be able to pivot in all directions on the top of the upper cross-piece of the crusher (not illustrated), the bearing means for the jack being advantageously of the type described in application Serial No. 185,370, filed April 5, 1962, now Patent No. 3,107,868, which has also not been illustrated, in order to simplify the drawing.

Jack **4** is supplied with hydraulic fluid through a conduit **5** connected through a rotary coupling **6** with a conduit **7** leading to the discharge end of a compressor **8** driven by an electric motor **9**. The intake **10** of the compressor **8** is connected to a hydraulic-fluid tank (not illustrated). A non-return valve **11**, which allows passing of the fluid only from compressor **8** to jack **4**, is inserted in conduit **7** to which is connected an overload oil-pressure circuit-breaker **12** including a stud **13** the position of which is adjustable and with which cooperates a pointer **14**, said assembly being arranged in such a manner as to establish a contact between the pointer **14** and stud **13** when the pressure in conduit **7** reaches a value predetermined by the position of stud **13**. Said stud **13** is connected to one of the terminals **15** of circuit-breaker **12**, pointer **14** being connected to the other terminal **16**. Finally, a conduit **17**, on which is inserted an electrically controlled valve **18** actuated by a relay **19** which is adapted to open the valve when energized, is branched on conduit **7**, at a point between jack **4** and circuit-breaker **12**, said conduit **17** leading to the hydraulic-fluid tank in which plunges the inlet pipe **10** of compressor **8**. Relay **19** is energized through a timing contactor **20** the opening of which is controlled by the excitation of a relay **21** arranged in such a manner as to close thereafter, after a predetermined period of time, relay **19** being, in turn, supplied through said circuit-breaker **12**.

The supply circuit of motor **9** driving compressor **8** has inserted therein a relay-controlled switch **22** adapted to be closed when its control relay **23** is energized. Said relay **23** is supplied through a timing contactor **24** controlled by a relay **25** across the supply circuit of which is inserted a push-button switch **26** the actuation of which is effected by a rod **27** integral with the movable piston of jack **4**, the length of said rod being adjustable, as at **27A**, so that the circuit of relay **25** is disconnected as soon as the crusher cone **2**, lifted by the action of jack **4**, will reach the desired position to effect crushing at the desired size, said position being predetermined by the adjustment of the length of rod **27**.

The energizing of relay **25** of contactor **24** causes the starting of the timing mechanism which, after a predetermined interval of time, closes the supply circuit of solenoid **23**. The de-energization of said relay **25** results in the instantaneous opening of said circuit.

The above described device operates as follows:

In normal operation, the crusher cone **2** is maintained by the pressure in jack **4** at its upper position as determined by adjusting the length of rod **27**. Contact **26**

is broken, the relays 25 and 23 are de-energized, switch 22 is opened and motor 9 is stopped.

Should a crush-resisting piece of material—for instance a metallic piece—engage into the crusher, the presence thereof between cone 2 and ring 3 will produce, during the gyratory motion of the cone, a reaction force the vertical component of which exerts a downwardly directed stress on shaft 1, thus tending to increase the pressure in jack 4 and, consequently, in conduit 7. As soon as said pressure exceeds the value predetermined by the adjustment in position of stud 13 of circuit-breaker 12, the energizing circuit of relay 21 of the timing contactor 20 is closed, resulting, on one hand, in the closing of said contactor 20, and consequently in the excitation of relay 19 and in the opening of the electric valve 18, and, on the other hand, the starting of the timing mechanism which keeps contactor 20 closed. The hydraulic fluid contained in the jack will escape through conduit 17 and return to the fluid tank. The pressure drops in jack 4, the piston of which is lowered, thus causing lowering of cone 2. On account of the pressure fall in conduit 7, the contact between pointer 14 and stud 13 of circuit-breaker 12 is cut off, thus disconnecting the supply of relay 21, but the timing mechanism of contactor 20 is adjusted so as to maintain relay 19 energized during the necessary period of time for the totality of the fluid contained in jack 4 to be evacuated. Cone 2 therefore continues its downward movement until it reaches its lowermost possible position and the metallic piece may be freely discharged if its size is acceptable to the apparatus. If the size thereof is too large, it will be but slightly calendered between cone 2 and ring 3 and the apparatus will bear but a comparatively low excess of stress, which is thus less liable to cause serious damage.

Furthermore, the drop of the jack piston simultaneously causes rod 27 to be driven downwards and contact 26 to be closed whereby relay 25 is energized, which starts the timing mechanism of contactor 24. Said timing mechanism, after a period of time predetermined by suitable prior adjustment thereof and which is that necessary to enable crusher cone 2 to reach its lowermost position, and the crush-resisting pieces of material to escape from between cone 2 and ring 3, spaced a maximum distance from one another, will close said contactor 24, causing the energizing of relay 23, the closing of contactor 22 and the starting of motor 9 driving compressor 8. Electric valve 18 having closed in the meantime, the hydraulic fluid is forced into jack 4 from the tank and the pressure is progressively restored in the jack, causing the return of cone 2 to its normal position. Rod 27 will then act on switch 26 which opens, disconnecting the supply of relay 25 and thus de-energizing relay 23, opening contactor 22 and breaking the current to motor 9, which stops.

It is obvious that the various details as to the design and type of the contactors, relays, valves and the like may be varied and selected at will by anyone skilled in the art, while many modifications and variations may be brought to the devices as above described and illustrated, without departing from the scope of the invention.

Thus, as regards particularly rod 27 which is integral with the piston of jack 4, and switch 26 which is stationary with respect to the crusher ring, the reverse arrangement might be adopted without any difficulty. On the other hand, any means other than a switch directly actuated by the movement of the piston may be adopted to cut off the supply circuit of motor 9; thus, the control of the position of the shaft may be ensured by measuring the volume of hydraulic fluid admitted into the chamber of jack 4 under the piston thereof by means of an electrically recording volume meter incorporated in the conduit 7 in the manner shown in FIGURE 3, or if a double-acting jack 35 is utilized, by measuring the volume of the fluid expelled from the upper chamber of the jack above the piston thereof through the use of a volume meter 36, as is shown in FIGURE 4, or again the pressure established in said upper chamber or in an accumulator wherein the fluid may be delivered from said upper chamber through the use of a pressure gauge 38, as is shown in FIGURE 5, each controlling, according to the case, the switch inserted in the circuit of relay 25, or any other similar breaking and making device for the supply of motor 9.

It is also possible to consider replacing the assembly formed by rod 27 and contact 26 by a different arrangement, in order to provide an easier adjustment of the size of the crushed material. It is apparent, in the case of the arrangement shown at FIGURE 1, that when the crushing size i.e. the limit height reached by the crusher cone during the lifting thereof is to be varied, it is necessary to vary the length of rod 27 or the vertical position of contact 26, which requires a hand control which has to be carried out at the top of the crusher and is obviously quite uneasy. To obviate this drawback, the breaking of the supply circuit of motor 9 driving compressor 8 may be controlled by means of a switch actuated by an adjustable device, responsive to a parameter of the current flowing in a circuit in which a device is inserted capable of causing said parameter to be progressively varied by relatively shifting two elements, one of which is stationary with respect to the framework of the crusher and the other integral with the shaft of the crusher cone.

An embodiment of such an arrangement is illustrated at FIGURE 2, wherein are again shown the various elements of the crusher, viz, crusher cone 2 mounted on shaft 1 integral with the piston of jack 4 supplied through conduit 5 connected by means of swivel coupling 6 to conduit 7 through which feeds the hydraulic fluid. The remainder of the supply circuit and the corresponding electric control circuits are the same as those described hereabove in connection with FIGURE 1, except that contact 26 is substituted by a contact 26*a* controlled by the pointer of a galvanometer 29 on the measuring scale of which contact 26*a* may be moved as desired. The galvanometer is supplied through line 30 in which is inserted a rheostat 31 comprising a fixed resistance with respect to the framework (not shown) of the crusher and a slide 32 integral with shaft 1.

When, after having moved downwards on account of the opening of the electrically controlled valve for the discharge of the hydraulic fluid, as previously described, shaft 1 rises again under the action of the fluid forced anew into the jack, slide 32 will simultaneously rise along resistance 31.

The resistance of the circuit decreases progressively, the intensity of the current in said circuit increases and the galvanometer pointer moves until it reaches the point where it disconnects contact 26*a*, thus bringing about the stopping of the motor-compressor 8, 9 unit and consequently that of the rising movement of shaft 1 and cone 2. It may be seen that the top position of cone 2 and, consequently, the crushing size may be adjusted by simply moving contact 26*a* on the galvanometer scale.

It should of course be understood that the above described embodiment is essentially of a diagrammatic nature, and more particularly as to the maximum contact galvanometer, and that any other type of device may be used instead, having a similar function.

As is shown in FIGURE 6, it is also possible to use a photosensitive cell 40 connected across the galvanometer 29 and impressed by a light source 41, a screen 42 of decreasing transparency integral with shaft 1 being inserted between said cells and said light source in such a manner that the luminous flux received by the cell varies so that the intensity of the current flowing through the galvanometer increases, in proportion as shaft 1 with cone 2 also raise.

What we claim is:

1. A device for controlling and adjusting the opening motion and the resetting in position of the crushing

cone of a gyratory crusher in case a crush-resisting piece of material passes through the crushing members of said gyratory crusher, the cone-supporting shaft of which is supported from a hydraulic jack fed by a source of hydraulic pressure fluid, said device comprising means responsive to the pressure of the hydraulic fluid against the piston of said jack, a pressure relieving system for returning hydraulic fluid to said source, said system including a discharge valve, means integral with said pressure responsive means to actuate said discharge valve when the fluid pressure reaches a predetermined value, means independent from said pressure for maintaining said valve in the open position thereof for a predetermined time after the opening thereof to assure the release of a crush-resisting piece, means for feeding the hydraulic fluid under pressure from said source to the jack piston, means for initiating the operation of said feeding means at the end of a predetermined time from said opening position of said discharge valve, and means for interrupting said feeding of the fluid as soon as the crusher cone has been restored to its operating position.

2. A device as claimed in claim **1**, wherein the discharge valve is an electrically controlled valve and the pressure sensitive means comprise a manometric circuit-breaker, the electrically controlled discharge valve having an energizing circuit controlled by said circuit-breaker, and said means for maintaining said discharge valve open include a timing mecahnism adapted to actuate the energizing of said discharge valve.

3. A device as claimed in claim **1**, wherein said means for feeding the hydraulic fluid under the jack piston include a normally inoperative motor driven compressor.

4. A device as claimed in claim **3**, wherein said means for initiating the feeding of the hydraulic fluid into the jack and the interrupting of said feeding includes a timing contractor controlling the supply circuit of the electric motor of the compressor, a switch inserted in the operating circuit of said motor and controlled by means responsive to the position of the piston in the jack cylinder, said contactor, said switch and said position-responsive means being arranged in such a manner that said electric motor operating circuit is closed at the end of a predetermined interval of time from the instant when said piston has left its position corresponding to the normal operating position of the crusher cone and opened as soon as the piston has again reached said position.

5. A device as claimed in claim **4**, wherein said position responsive means comprise a volume meter inserted in the input conduit for the hydraulic fluid under said piston jack.

6. A device as claimed in claim **4** wherein said jack is a double-acting jack having a secondary end remote from said shaft, and said position responsive means is connected to a conduit of the hydraulic fluid from said secondary end.

7. A device as claimed in claim **4**, wherein said jack is a double acting jack having a secondary end remote from said shaft coupled to a receiver, and said position responsive means include a manometric circuit-breaker responsive to the pressure occurring in the space above the piston of said double-acting jack.

8. A device as claimed in claim **4**, wherein said position responsive means include an electric device comprising two relatively movable elements one of which is stationary relative to the crusher framework, whereas the other is integral with the crusher cone shaft, and arranged in such a manner that the relative movement of said two elements causes the variation of a parameter of an electric current flowing through a circuit in which is inserted a device responsive to said parameter and adapted to actuate said above mentioned switch, said electric device includes a photosensitive cell energized by a light source and a mobile screen with decreasing transparency inserted therebetween, said cell and said screen being respectively said two relatively movable elements.

9. A device as claimed in claim **4**, wherein said position responsive means comprise a photosensitive cell energized by a light source and a mobile screen with decreasing transparency inserted therebetween, and means coupling one of said screen and said photosensitive cell for movement thereby.

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