Dec. 9, 1952 K. GAULDIE 2,620,629

HYDRAULICALLY-OPERATED CRUSHER OF RECIPROCATING TYPE

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FIG. 1

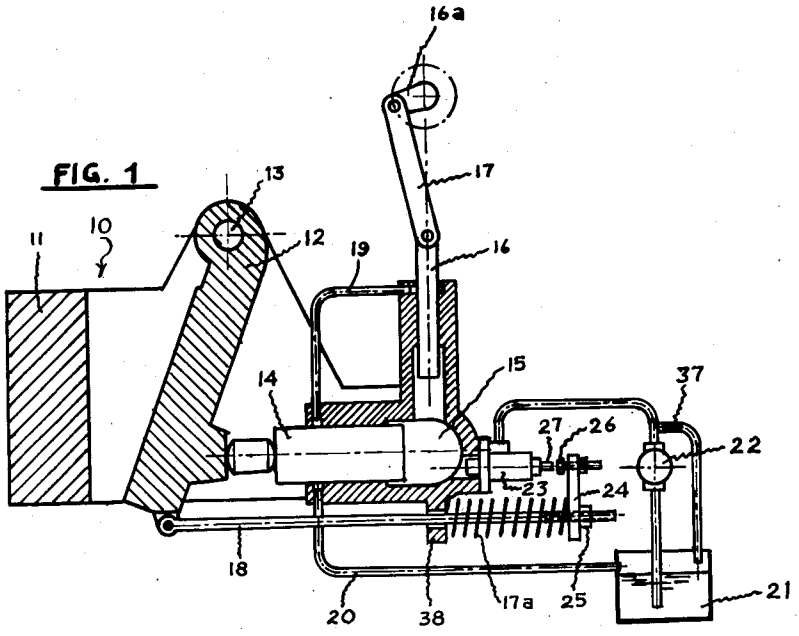
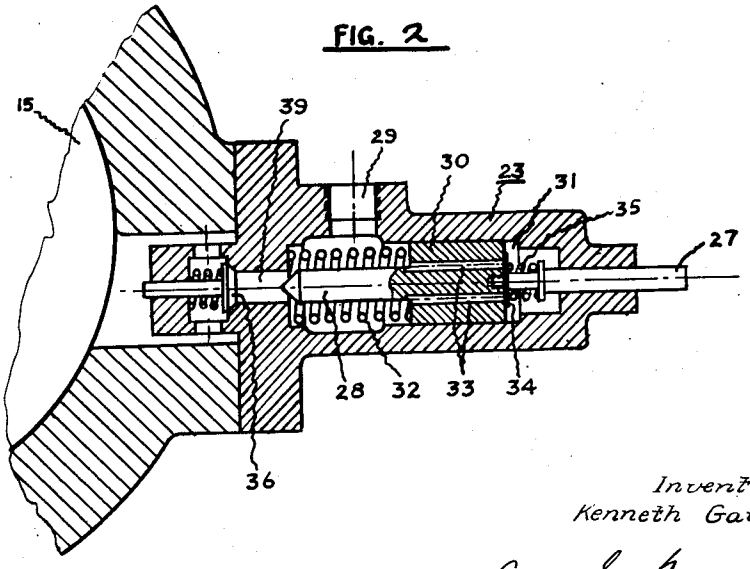


FIG. 2



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HYDRAULICALLY-OPERATED CRUSHER OF RECIPROCATING TYPE

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The present invention relates to hydraulically operated crushers of the reciprocating jaw type in which energy is transmitted to the reciprocating jaw through a ram to which pulsating pressure is applied and is primarily concerned with means for compensating for leakage past the ram, or elsewhere in the hydraulic system, with the object of maintaining constancy of the limits between which the jaw normally operates.

In crushers of the closed-hydraulic-system type, it is necessary to add liquid to the hyrdaulic system as leakage occurs from it; otherwise the volume of liquid in the system would diminish, the reciprocating member would oscillate between receding limits, and the mean opening between the jaws would increase. Means to this end which has previously been proposed comprises a stop against which the ram contacts towards the end of its return stroke and which consequently defines the backward limit of movement of the swing jaw. In consequence of the leakage which occurred in the preceding cycle of operation, the ram and jaw are arrested before the plunger by which the pulsating pressure is developed, has reached the end of its induction stroke. A sub-atmospheric pressure is consequently developed in the hydraulic system during the remainder of the induction stroke of the plunger, and liquid enters the system through an automatic valve in amount equal to the leakage which occurred during the preceding cycle. This method is open to the objection that, if leakage should be appreciable, the momentum of the massive moving parts at the instant of their arrest might be large and might involve heavy blows on the stop. In a hydraulically-operated crusher a relief valve to protect the structure against damage by tramp steel caught between the jaws would normally be provided, and it is when the relief valve operates for this or other reason that the above mentioned objection applies in the highest degree. In such case, the leakage from the system during a working stroke might be half the displacement of the plunger. On the succeeding return stroke, the heavy jaw and ram would be arrested when moving at their maximum velocity; the corresponding blow would be heavy and might be destructive.

According to the method employed in the present invention, make-up liquid, under the control of external regulating means, enters the hydraulic system at mean rate equal to the mean rate at which leakage occurs from the system. In the embodiment described with reference to the accompanying drawings, make-up liquid enters the

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hydraulic system from an external source of pressure through a valve, the opening through which is so controlled by the movements of the reciprocating jaw or associated part that the average rate of inflow of make-up liquid into the hydraulic system is equal to the average rate of leakage from the system. The volume of liquid in the hydraulic system is thereby maintained constant and, without the use of any mechanical stop, a definite range of movement of the oscillating jaw is maintained and all possibility of dangerous impact is avoided.

Referring to the drawing, Fig. 1 is a view somewhat diagrammatic and partly in cross-section illustrating my invention, and Fig. 2 is a longitudinally cross-sectional view of a valve used in Fig. 1 and on an enlarged scale compared to Fig. 1. Referring to Fig. 1, I have shown a jaw crusher 10 having a fixed jaw 11 and a movable jaw 12 mounted on a pivot 13. The swing jaw 12 is moved in its crushing stroke toward the fixed jaw 11 by means of a ram 14 in a hydraulic chamber 15. A plunger 16 which may be reciprocated by any suitable source of power through a crankshaft 16a and connecting rod 17 also operates in the hydraulic system to drive the ram. The return stroke of the jaw 12 is caused by gravity and the action of the spring 17a held in compression between a detent 24 and an abutment 38 acting on the rod 18 which is connected to the lower end of the movable jaw. Leakage past the plunger 16 and the ram 14 is conducted by the pipes 19 and 20 to a sump 21. Make-up fluid is delivered by a pump 22 from the sump 21 to the hydraulic chamber 15 through a valve 23. The detent 24 is mounted on and movable with the rod 18 and may be adjusted along the rod by a nut 25. The detent 24 carries a tappet 26 in a position whereby it may engage the stem 27 of the valve 23.

The valve 23 as illustrated in Fig. 2 comprises a regulating needle 28 which is freely movable in the closing direction and a dashpot which constrains the needle to move slowly in the opening direction. The dashpot comprises a piston 30 on which the needle 28 is mounted, a spring 32 which tends to move the piston and needle in the opening direction, channels 33 communicating between the two sides of the piston and a valve 34 of the non-return type, for example a disc valve which normally closes these channels.

When a force in excess of the tension of the spring 32 is applied to the end of the valve spindle 27 liquid is displaced past the disc valve 34 from one side of the piston 30 to the other

and the needle 28 moves freely in the closing direction.

When that force is relieved, the piston 30 and the needle 28 move in the opening direction under the influence of the spring 32 and the liquid tends to flow backwards through the channels 33. The disc valve 34 then closes and the piston and needle move in the opening direction at slow rate determined by the rate of leakage between the piston 30 and its cylinder 31. A non-return valve 36 is shown between the needle valve and the hydraulic cylinder.

In the normal operation of the crusher, make-up enters the hydraulic system only during the return strokes of the ram 14 when the pressure in the system is low; and it is only against the low pressures then existing that the make-up pump 22 must be designed to discharge. Under these conditions the non-return valve 36 permits make-up to enter the hydraulic system. During the working strokes of the ram when the pressure in the hydraulic system is normally much higher than the pressure developed by the make-up pump 22, the non-return valve 36 closes automatically and prevents escape of working liquid from the hydraulic cylinder 15 through the make-up entrance.

The capacity of the make-up pump 22 is in excess of the maximum rate of leakage occuring past the ram 14 and plunger 16 under any condition of normal operation of the crusher. If the make-up pump is of positive displacement type its surplus capacity is by-passed through relief valve 37 and is normally used for the lubrication of the plunger-crankshaft and other bearings and is returned ultimately to the sump 21. Any necessary cooling system may be incorporated in the circuit of the make-up pump.

When the crusher is in normal operation the tappet 26 barely touches the end of the spindle 27 at the limit of the forward stroke of the former and moves the needle 28 slightly in the closing direction. Free forward movement of the needle valve is permitted by the disc valve 34 which permits free passage of liquid from left to right of the piston 30 through the ports 33 when pressure in excess of the tension of the opposing spring 32 is applied to the end of the spindle 27. At all other times the needle moves slowly in the opening direction, the rate of speed being determined by the leakage which takes place past the piston 30 or through a restricted aperture especially provided in the disc valve 34. The mean position of the needle and the mean rate at which liquid can enter the hydraulic system are, therefore, determined by the location of the tappet when at the forward limit of its stroke and by the slight distance through which the needle moves in the opening direction during the remainder of the period of oscillation of the tappet. As the valve spindle is touched by the tappet several times a second the position of the needle is practically fixed in relation to the position of the tappet and of the swing jaw at the forward limits of their strokes.

Let it be assumed for purpose of explanation that during a period of shut-down of the crusher, liquid has leaked from the hydraulic system so that the jaw has swung back from its normal setting and that, under these conditions, the crusher is started up. In this assumed case the needle valve 28 is wide open and the flow through it exceeds considerably the rate at which leakage occurs from the hydraulic system. With every stroke of the crusher the volume of liquid in the hydraulic system, therefore, increases and the ram and the swing jaw oscillate between advancing limits until, after a short period of operation, the tappet 26 at the limit of its forward strokes contacts the end of the valve spindle 27 and moves the needle 28 step-by-step in the closing direction until the normal position previously described is attained; that is, the position at which the rate of make-up inflow is throttled into equality with the rate of leakage. After that condition has been established the volume of liquid in the hydraulic system remains almost constant and the ram and swing jaw oscillate between fixed limits.

If under operating condition the needle valve 28 should have been moved slightly too far by the tappet 26 at the end of the stroke of the latter the rate of make-up inflow into the hydraulic system is reduced to slightly less than the rate at which leakage occurs from the system. The swing jaw consequently tends to oscillate between receding limits and at the end of the next stroke contact between the tappet 26 and the valve spindle 27 is not established. The needle 28, therefore, continues to move in the opening direction during the succeeding stroke and any slight increase in the close setting of the jaws which may have occurred in any stroke is corrected in the succeeding strokes. A similar correction occurs in the reverse direction if the rate of leakage should be less than the rate at which make-up can enter through the valve 28. The swing jaw is consequently constrained by the system to oscillate between limits determined by the position of the valve needle 28 at which equilibrium between leakage and make-up occurs.

If the setting of the tappet 26 is moved relative to the swing jaw the limits between which the latter oscillates will be changed. If, for example, the tension rod nut 25 is screwed to move in a direction away from the jaw, the tappet 26 will move back with the nut 25 and it will not contact the valve spindle 27 at the end of its immediately succeeding strokes. The needle valve 28 as previously described will continue to move in the opening direction and inflow of make-up in excess of leakage would occur and the swing jaw and ram would oscillate between advancing limits until, after a few strokes, contact between the tappet 26 and the valve spindle 27 had been reestablished. Thereafter, the jaw would continue to oscillate between fixed limits at a closer setting than before. Similarly if the tension rod nut 25 is moved forward on the rod 18 toward the jaw, the corresponding movement of the tappet will result in a wider setting of the jaw opening. The mounting of the tappet on the outer end of the tension rod provides, therefore, a simple and convenient means whereby the setting of the swing jaw may be adjusted.

It will be noted that in normal operation the position in space of the tappet 26 at the end of its forward stroke is determined by the position of the valve needle 28 at which equilibrium between leakage and make-up occurs. That is, the location of the tappet at the forward end of its stroke is fixed in relation to the frame of the machine. That definite location of the tappet is, therefore, fixed in relation to the inner abutment 38 of the tension rod spring.

It follows that, after an adjustment of the jaw setting has been made, the original working length and tension of the tension rod spring 17a are automatically reestablished and that no separate adjustment of this tension is required after

an adjustment of jaw setting has been made. The tension of this spring is determined by its working length which, in turn, is determined by the location of the tappet **26** at the end of its forward stroke, in relation to the equilibrium position of the valve spindle **27**. It is, therefore, adjustable by appropriate change in that relative position. For purposes of tension spring adjustment, the tappet **26** may as indicated in Fig. 1, be mounted for a screw adjustment on the detent **24**.

If the tappet **26** is adjusted in a backward direction relative to the detent **24**, equilibrium between leakage and make-up will not be reestablished until the detent, at the forward limit of its stroke, has moved an equal distance in the reverse direction. Backward adjustment of the tappet relative to the detent on which it is mounted has, therefore, the effect of shortening the working length of the tension spring **17***a* and of increasing its mean tension. Forward adjustment of the tappet has the reverse effect, and it is primarily with the object of adjusting the tension of the spring **17***a* that tappet adjustment is provided.

Any longitudinal adjustment of the tappet has also the effect of changing the jaw setting by equal amount; and minor adjustments of jaw setting may be effected in this manner. It will also be evident that if an axially adjustable anvil were provided on the end of the valve spindle **27**, adjustment of jaw setting could be effected by corresponding axial adjustment of the anvil along the spindle **27** without stopping the machine. Spring tension would, however, be changed by movement of the anvil and this method is, therefore, more particularly applicable for minor setting adjustments which it may be convenient to make when the crusher is in operation.

A relief valve would normally be included in the hydraulic system of this or any hydraulically operated jaw crusher as a protection against damage by tramp steel, or other uncrushable obstruction caught between the jaws. It is one of the advantages of a crusher made according to this invention that a relief valve provides such protection and also provides for automatic ejection of the obstruction and for subsequent automatic reset of the jaw opening.

When the swing jaw and ram are arrested by tramp steel, liquid escapes from the hydraulic system through the relief valve. On the succeeding return stroke of the plunger **16** the swing jaw **12** moves back beyond its normal limit and permits the obstruction to descend in a hopper. On the next active stroke of the plunger the jaw is again arrested and the relief valve again operates and more liquid escapes from the hydraulic system. On the next return stroke of the plunger the swing jaw moves still further back and the obstacle descends still further in the hopper. This process proceeds until the obstruction reaches the outlet and is discharged. The system then continues to operate in a manner which has already been described in connection with the starting up of the crusher after a shut-down to bring the swing jaw automatically to its normal setting.

While I have described my invention applied to the control of the jaw movement from the closed setting thereof, it is apparent that it may be controlled from other settings. For example the operation of the jaw may be controlled from the open setting. In this case the needle valve could be of the normally closed type and if moved in the opening direction by a tappet when the swing jaw is at the backward limit of its return stroke and if the valve at other times tends to close, its controlling operation would be essentially the same as that of the valve illustrated in Fig. 2.

If the range of oscillation of the swing jaw were controlled from the backward limit of the oscillating parts special means would, however, be required to permit the swing jaw to move back beyond that limit when freeing itself from tramp iron. For this and other practical reasons control of the range of oscillation of the jaw from the forward limit of its reciprocating movement is mechanically simpler and is preferred.

According to the latter method (that is, according to the invention as illustrated in the drawing) the valve imposes no restriction whatever on the backward movement of the jaw and, in normal operation, it offers no material restraint on forward movement of the jaw. It might occur, however, that with the crank **16***a*, at top centre, the tappet **26** might be adjusted into contact with the valve spindle **27**, and that the crusher might then be started. In such case damage would occur if the valve spindle were not free to move through a distance equal to the complete stroke of the tappet.

For that reason the diameter of the outlet port **39**, of the valve illustrated in Fig. 2, slightly exceeds the diameter of the needle, the length of the port exceeds the stroke of the tappet and the valve is otherwise designed to permit an axial movement of the valve spindle in excess of the stroke of the tappet.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a crusher having a reciprocatable jaw, a ram cylinder, and a raw in the cylinder, a hydraulic system for operating the jaw to produce crushing strokes thereof comprising power-transmitting liquid in the cylinder, and means for adding make-up liquid to the system to compensate for leakage from it comprising an external source of liquid at a pressure higher than the minimum pressure occurring in the ram cylinder, means forming a liquid passage connecting said source with the ram cylinder, a valve controlling liquid flow through the passage, said valve including an element movable to control said liquid flow, and a member mechanically connected to the jaw and operable thereby to move said element.

2. In a crusher having a reciprocatable jaw, a ram cylinder, and a ram in the cylinder, a hydraulic system for operating the jaw to produce crushing strokes thereof comprising power-transmitting liquid in the cylinder, and means for adding make-up liquid to the system to compensate for leakage from it comprising an external source of liquid at a pressure higher than the minimum pressure occurring in the ram cylinder, means forming a liquid passage connecting said source with the ram cylinder, a valve in the passage, said valve having two elements, one of said elements being relatively movable with respect to the other to adjustably control flow of liquid through the valve, and a member mechanically connected to the jaw and operable thereby to move said one of the elements.

3. In a crusher having a reciprocatable jaw, a ram cylinder, and a ram in the cylinder, a hydraulic system for operating the jaw to produce crushing strokes thereof comprising power-transmitting liquid in the cylinder, and means for adding make-up liquid to the system to com-

pensate for leakage from it comprising an external source of liquid at a pressure higher than the minimum pressure occurring in the ram cylinder, means forming a liquid passage connecting said source with the ram cylinder, an adjustably movable valve in the passage controlling flow of liquid therethrough, said valve having a portion fixed thereto and extend externally of the passage, said portion being movable with the valve to adjust the position thereof, and a member connected to the jaw and reciprocal therewith, said member being in opposed, disconnected relation to said valve portion and said valve portion being engageable by said member for adjustment in one direction thereby only when the jaw is approaching a limit of each of its crushing strokes.

4. A crusher as defined in claim 3, said member comprising a tappet, a reciprocally-mounted rod carrying said tappet, said rod having a pivotal connection with the jaw, and means urging the latter and said rod in a direction opposite to the direction of said crushing strokes.

5. A crusher as defined in claim 3, said valve being freely movable in one direction, resilient means for moving said valve in its opposite direction, and dashpot means for restricting to a slow rate the movements of said valve in its opposite direction.

6. In a crusher having a reciprocatable jaw, a ram cylinder, and a ram in the cylinder, a hydraulic system for operating the jaw to produce crushing strokes thereof comprising power-transmitting liquid in the cylinder, and means for adding make-up liquid to the system to compensate for leakage therefrom comprising an external source of make-up liquid at a pressure higher than the minimum pressure occurring in the ram cylinder, means forming a liquid passage connecting said source with the ram cylinder, valve means in the passage for controlling flow of liquid therethrough and having an opening,

a valve movable to close and open said opening, said valve being freely movable in one direction, resilient means urging the valve in its opposite direction, said valve having a portion fixed thereto and extending externally of the passage, a member connected to the jaw and reciprocal therewith, said member being in opposed, disconnected relation to said valve portion and said valve portion being engageable by said member for movement in said one direction only when the jaw is approaching a limit of each of its crushing strokes.

7. A crusher as defined in claim 6, wherein said resilient means comprises a piston on which said valve is mounted, a resilient element engaging one end of the piston and urging it in said opposite direction of the valve, means forming a liquid passage communicating with both ends of said piston, and a one-way valve controlling liquid flow through said passage.

8. A crusher as defined in claim 6, wherein said resilient means comprises a piston on which said valve is mounted, a resilient element engaging one end of the piston and urging it in said opposite direction of the valve, said piston having a liquid passage extending in an axial direction therethrough, and a one-way valve controlling liquid flow through said passage.

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