

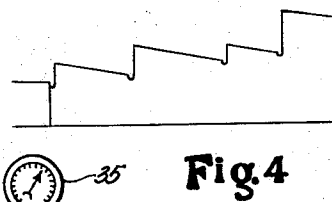
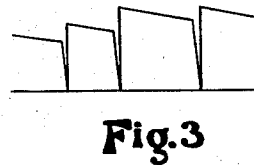
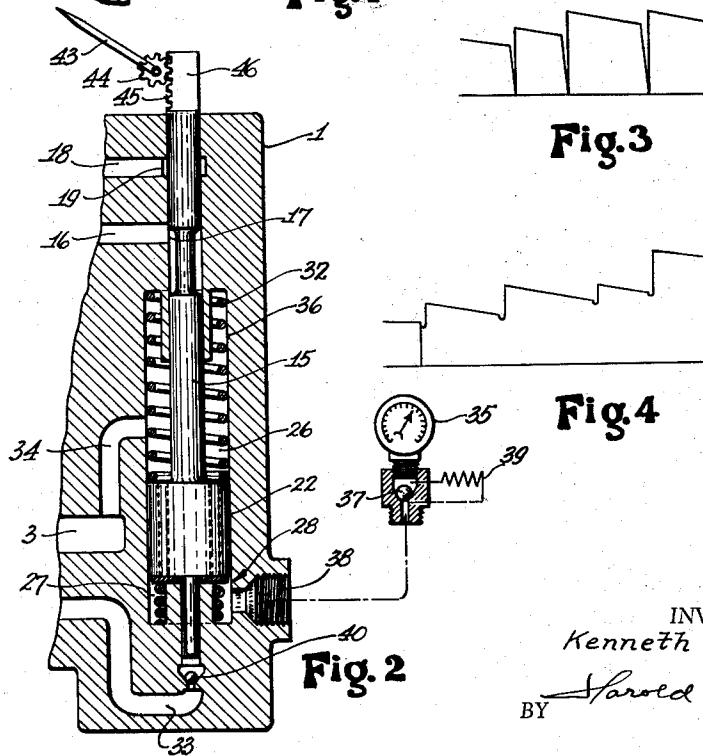
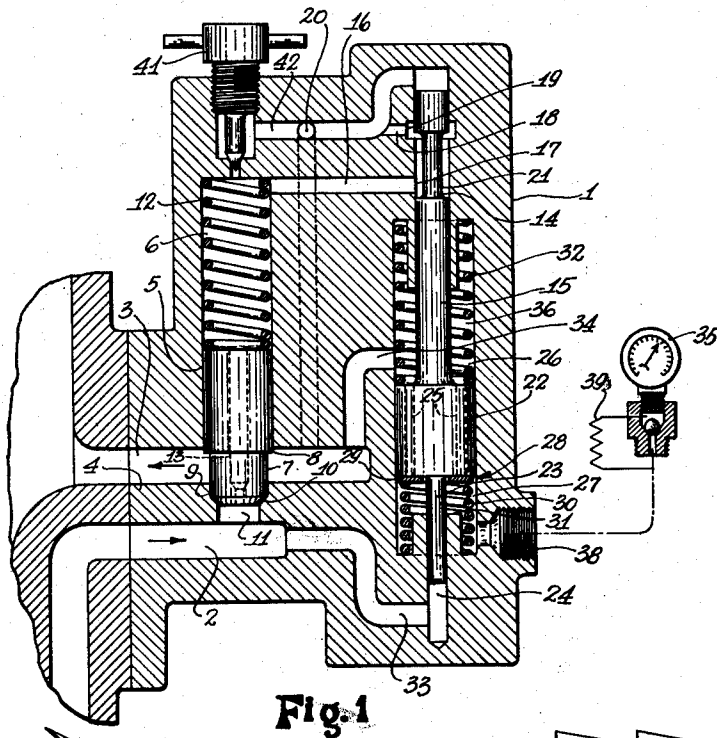
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PILOT OPERATED RELEASE VALVE STRUCTURE

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PILOT OPERATED RELEASE VALVE STRUCTURE
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1 Claim. (Cl. 137-491)

This invention relates to a pilot operated release valve structure.

In hydraulic systems of various types, dangerous pressures of short duration frequently occur, such pressures resulting in damage to the equipment involved.

For instance, in hydraulically-operated jaw crushers of the type described in Canadian Patent 492,360, protection against damage by jamming of the jaw is provided by an ordinary relief valve but a series of heavy and possibly damaging blows are transmitted through the machine and its driving mechanism during the step by step descent of a large piece of tramp steel through the hopper of the machine.

It is a general object of the present invention to provide an improved valve structure wherein closing movement of a pilot valve, after it has been operated by a high pressure impulse, is so impeded that it remains open for a period long enough to enable a main valve to open widely and permit the pressure in a hydraulic system to fall to low value and to remain at low value for a predetermined period of time.

Another more specific object of the invention is to provide a pilot operated release valve structure for a hydraulically-operated jaw crusher having a moving jaw and a feed hopper which will permit the pressure in the hydraulic system of such jaw crusher to fall to low value and to remain at such low value for a period of time, covering several strokes of the jaw, which is long enough for a piece of tramp steel to be ejected by step by step descent through the hopper.

The invention resides in a pilot operated release valve structure for a hydraulic system comprising a main valve, a pilot valve controlling the operation of said main valve, and movable to open position to open said main valve and to closed position to close said main valve, a reciprocally mounted piston movable in response to a predetermined pressure in said system and connected to said pilot valve to move said pilot valve to open position, a spring urging said pilot valve to closed position, a dashpot piston of larger diameter than said first piston carried by said pilot valve to resist closing movement thereof, said dashpot piston having a passage for hydraulic fluid extending from end to end thereof to permit free opening movement of said pilot valve and a non-return valve closing said passage during the closing movement of said pilot valve.

The invention will be described with reference to the accompanying drawing, in which

FIGURE 1 is a sectional elevation of a valve structure in accordance with the invention,

FIGURE 2 is a sectional elevation of the pilot valve showing another position thereof and including modifications thereof, and

FIGURES 3 and 4 are diagrammatic indications of readings of a pressure gauge.

In the drawing, 1 is a valve body having a passage 2 in communication with a hydraulic system and a discharge outlet passage 3 which, in the modification shown, is substantially parallel to passage 2 providing a wall 4 in the valve body between the passages.

A main valve 5 is reciprocally mounted in a cylinder 6 in the body. The valve, as shown, is of cylindrical form and has an end section 7 of relatively smaller diam-

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eter than the main section 8 thereof. The valve extends across passage 3 and, in the closed position thereof, the end portion of the small diameter section 7 extends into a recess 9 in wall 4 and is seated on an annular valve seat 10 in the wall. A valve inlet 11 in wall 4 places the passage 2 in communication with the end of the valve in the closed position thereof and with the outlet passage 3 in the open position thereof. A spring 12, in cylinder 6 imposes closing pressure on the valve 5.

Valve 5 has an axial opening 13 providing constant restricted communication between passage 2 and cylinder 6. Thus, the hydraulic pressure in passage 2 and cylinder 6 will be the same but since the diameter of valve section 8 is greater than that of the valve seat 10, the valve is normally pressed against the seat.

Reciprocally mounted in a cylinder 14 in the valve body is a pilot valve 15. A passage 16 has a port 17 in the wall of cylinder 14 and provides communication between pilot valve cylinder 14 and main valve cylinder 6. A second passage 18 has a port 19 in the wall of cylinder 14 and provides communication through a branch passage 20 with outlet passage 3. Valve 15 has an annular recess 21 therein which in the open position of the valve places ports 17 and 19 in communication and connects the main valve cylinder 6 to the outlet passage 3, and in the closed position of the valve interrupts such communication to disconnect the main valve cylinder 6 from the outlet passage 3.

Mounted on pilot valve 15 is a dashpot piston 22 of considerably larger diameter than the valve and having reciprocal movement in a cylinder 36 of corresponding size. Depending from dashpot piston 22 is a valve actuating piston 23 of relatively small diameter and having reciprocal movement in a cylinder 24. Axial passages 25 extend through dashpot piston 22 to provide communication between the portions 26 and 27 of cylinder 36 at the ends of piston 22. Such communication is controlled by a non-return valve 28 which may comprise a disc 29 held in releasable engagement with the end of dashpot piston 22 in cylinder portion 27 by means of a light spring 30 in cylinder portion 27. It will be observed that valve 28 closes passages 25 during the closing movement of valve 15 and dashpot piston 22 but permits opening of the passages 25 during the opening movement of valve 15 and dashpot piston 22. The valve 28 engages a seat 31 adjacent the end of cylinder portion 27 in the closed position of the pilot valve. A spring 32 in cylinder portion 26 urges the pilot valve assembly 15, 22, 23 into closed position. The portion 27 of cylinder 24 below piston 23 communicates with passage 2 through a duct 33. The portion 26 above piston 23 communicates with passage 3 through a duct 34.

In operation, when the pressure in the hydraulic system and, therefore, in passage 2 rises to releasing value, the pilot valve assembly 15, 22, 23 rises against the reaction of spring 32 until the pilot valve places the main valve cylinder 6 in communication with the outlet passage 3. Opening movement of the pilot valve is, of course, unimpeded by the dashpot piston because of free flow of liquid through the passages 25 therein.

The pressure in the main valve cylinder 6 falls, therefore, to low value and remains so as long as the pilot valve remains open; and the main valve is opened fully by the pressure of the liquid in the valve inlet 11 and by the impact of the escaping liquid. The pressure in the hydraulic system falls, therefore, to low value and remains low as long as the pilot valve remains open. The pressure in the hydraulic system of a jaw crusher, for instance, may, therefore, remain at low value during the whole period of ejection of tramp steel.

Closing movement of the pilot valve 15 under the in-

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fluence of spring 32 when pressure in passage 2 falls will be resisted by the dashpot piston 22 which is rendered effective by closure of non-return valve 28, and proceeds at a rate dependent on the rate of leakage past the dashpot piston in the modification shown. Obviously as an alternative a separate valve-controlled passage could be provided to control the flow of liquid past the dashpot piston and thus the closing movement of the pilot valve.

All other conditions being the same, the time needed to close the pilot valve varies as the cube of the ratio D/d where d and D are the diameters of the pilot valve piston and the dashpot piston respectively. As the pilot valve piston may be quite small it is, then, an easy matter to ensure that the pilot valve shall remain open for a second, or longer if required, without the necessity for free clearances between the dashpot piston and its cylinder.

If the main valve 5 should be open when the pilot valve 15 should close, the main valve could close (if the spring 12 were weak) only as fast as liquid could enter the cylinder 6 through the opening 13; and the total time during which the main valve remains open may be made to depend, in part on the diameter of that opening. As, however, it is easy to maintain the pilot valve open for an appreciable time it may be arranged so that the pilot valve closing delay previously described be the preponderant component of the total delay.

If the main valve were to remain open during, for instance, ejection of tramp steel, some difficulty would be encountered in preventing air from being drawn in through it during the return strokes of the ram-operating plunger. That may be prevented by making the spring 12 strong enough to hold the valve on its seat except when actual discharge is taking place.

The pressure in the hydraulic system of a hydraulically-operated jaw crusher is likely to be near atmospheric during the period when the release valve is operating, except when discharge is taking place through it. If, then, the spring 12, is strong enough to overcome the pressure of the atmosphere over the area of the valve piston 8, the valve will open and permit discharge during an active stroke of the plunger but will close and be restored to its seat immediately the plunger comes to rest at the end of that stroke. Air cannot, therefore, be drawn into the system through the orifice 11, during the return strokes of the plunger.

The movement of the valve from open to closed position may draw a vacuous space in the cylinder 6, which space will thereafter be filled by liquid drawn in through the axial hole 13, in the valve 5, and through the pilot valve if still open.

A main purpose of the recessed seat 10 is to prevent the leakage that otherwise would occur if all air had not been expelled from the valve cylinder 6. Such air bubbles would be compressed at every active stroke of the plunger, and there would be corresponding movement of the valve off its seat. Leakage would not, however, occur to any serious extent because of the close fit of the valve nose in its bore above the seat. Without the recess, the rate of leakage could exceed the capacity of a leakage make up pump; and it would be impossible, until the air had been expelled from the valve cylinder, to get the crusher into effective operation.

The recessed seat also serves the purpose of causing the pilot valve to open wider than the minimum needed to open the main valve and to increase the period during which the pilot valve is effectively open.

When tramp steel jams the jaw of a jaw crusher the rise in pressure in the hydraulic system is likely to be rapid, and when the pilot valve has opened to an extent sufficient to operate the main valve the pressure is likely to be still rising. Discharge cannot, however, take place until the face of the main valve has risen to surface level. During the short instant while this is occurring the pilot valve will be still moving in the opening direction; and the amount of its opening is likely, therefore, appreciably to

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exceed the minimum necessary to operate the main valve.

The momentum of the pilot valve and associated parts at the instant of its opening tends also to make that valve over-run its minimum opening. These inertia effects will vary greatly with circumstances and may be great or slight according as jamming occurs when the jaw is near the middle or near the end of its stroke. In order that the period available for outfall of tramp steel may not be unduly prolonged and be the cause of unnecessary dumping of oversize material a mechanical stop may be provided to limit the amount of the opening of the valve and, therefore, the time during which it is effectively open.

As previously indicated, as long as the pilot valve and the dashpot piston are moving in the opening direction the non-return valve 28 permits liquid to flow past it into the space 27 below it and that space communicates with outlet passage 3 by way of axial openings 25 and duct 34; that is, the pressure in cylinder space 27 would be approximately atmospheric. Immediately the pressure peak is passed the motion of the pilot valve assembly is arrested, the non-return valve 28 closes, and positive pressure in cylinder space 27 is developed by the spring 32.

That pressure would depend, in part, on the pressure exerted on the pilot valve piston 23. But, in a jaw crusher, immediately after a crushing stroke of the ram propelling plunger is completed and the plunger commences its return stroke, the pressure in the hydraulic system and on the pilot valve piston 23 would fall substantially to atmospheric and the pressure in the cylinder space 27 would reach a peak which would depend upon the amount of compression of the spring 32. That compression would depend upon the peak pressure which had just been exerted on the pilot piston 23. It follows, therefore, that the peak pressure developed in the space 27 is proportional to the pressure maximum which, immediately previously, had been applied to the pilot piston 23, and that the pressure intensity of these maxima may be indicated in pounds per square inch, or other units, on a pressure gauge, such as is indicated at 35, connected to the space 27 by a passage 38.

As the backward movement of the pilot valve 15 and its dashpot piston 22 is very slow (say, a hundredth of an inch per second or less), the fall in pressure in the space 27 as the spring 32 extends is equally slow, and the peaks may, therefore, easily be read on the gauge. If the pressure gauge followed all the pressure variations in the cylinder 36 its indications would be somewhat as indicated in FIGURE 3. However, in such case, the gauge pointer would be subject to rapid backward and forward jerks which would be avoidable by use of a snubber in series with the gauge. Such a snubber may be a small non-return valve 37 in the passage 38 leading to the gauge (FIGURE 2) in parallel with a hydraulic resistance 39. The valve 37 permits the pressure in the space 27 to extend to the gauge 35 except when the pressure at the gauge is falling. Under such conditions the valve 37 is closed and the pressure at the valve can fall no more rapidly than the resistance 39 permits. The effect of the snubber is as indicated in FIGURE 4 and is such that only a slight pressure drop would occur at the gauge following any forward movement of the dashpot piston.

In FIGURE 2, the dashpot piston 22 is shown on its seat; and if the spring 32 should then be extended to its free length, there would, of course, be no pressure in the space 27 or on the pressure gauge 35. Should it be required that the pilot piston 23 should not move until some predetermined pressure has been exceeded, the position of the seat would be chosen accordingly.

FIGURE 2 illustrates a modification including a non-return valve 40 in the duct 33 leading to its cylinder 24 and therefore in series with the pilot valve piston. The valve 40 produces a retarding effect which is, of course, additional to that of the dashpot piston 22.

Means may be provided for manual unloading purposes. Referring to FIGURE 1, this means may comprise a hand

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operated valve 41 providing communication through a passage 42 with passages 18, 20, and discharge passage 3. Necessity for such means in a hydraulically operated jaw crusher would occur when, because of power failure when the machine is in operation, it should be necessary to start up against full hopper. In such case, the valve would be opened, start against low resistance would be made, liquid would escape from the hydraulic system, and as the machine ran up to speed the jaw would swing back. Start having been made, the valve would be closed and normal operation would be restored.

Should the compression of the spring 32 be zero when the dashpot piston is on its seat, as illustrated in FIGURE 2, the movement of the dashpot piston and the pilot valve 15 to the open position thereof would ordinarily be considerable, say, half an inch or more; and that movement would be applicable for indication of pressure peaks in the hydraulic system or for other purposes. To that end, the stem of the pilot valve 15 may be extended to the outside of the valve body, as indicated at 46, and any suitable indicating means applied to it. For instance, an indicating pointer 43, may be carried by a pinion 44 having engagement with a rack 45 on the extension 46.

I claim:

A pilot-operated hydraulic release valve comprising a valve body having therein a main valve cylinder, a pilot valve cylinder, a dashpot piston cylinder of larger diameter than said pilot valve cylinder and axially aligned therewith, a pilot valve piston cylinder of smaller diameter than said dashpot piston cylinder and axially aligned therewith, a hydraulic fluid inlet passage, and a hydraulic fluid outlet passage, said fluid inlet passage having a first orifice communicating with said fluid outlet passage and a second orifice communicating with said pilot valve piston cylinder, a cylindrical main valve member reciprocally mounted in said main valve cylinder and having a closed position closing said first orifice and an open position opening said first orifice, said main valve cylinder having a fluid-receiving zone surmounting said main valve member, said main valve member having a constantly open passage extending axially therethrough and leading from said inlet passage to said fluid-receiving zone to subject said zone to fluid pres-

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sure, said main valve member having a normally closed position in response to fluid pressure in said zone, a cylindrical pilot valve member reciprocally mounted in said pilot valve cylinder, a dashpot piston fixed to said pilot valve member and in sliding engagement with said dashpot piston cylinder, a pilot valve piston fixed to said dashpot piston and in sliding engagement with said pilot valve piston cylinder, said valve body having a first passage connecting said pilot valve cylinder with said main valve cylinder zone and a second passage connecting said pilot valve cylinder with said fluid outlet passage, said pilot valve member having an annular recess therein, a closed position closing said second passage to disconnect said first and second passages and an open position connecting said first and second passages through said recess to dissipate fluid pressure in said main valve cylinder zone and permit opening movement of said main valve member, spring means urging said pilot valve member into said closed position, said pilot valve member being movable to open position in response to fluid pressure on said pilot valve piston through said second orifice, passage means in said body providing fluid communication between said outlet passage and dashpot cylinder, means forming fluid flow ducts leading from said dashpot piston cylinder on one side of said dashpot piston to said dashpot piston cylinder on the other side of said dashpot piston to permit substantially free opening movement of said pilot valve member, and a non-return valve closing said ducts during closing movement of said pilot valve member whereby fluid leakage between said dashpot piston and cylinder retards said closing movement.

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