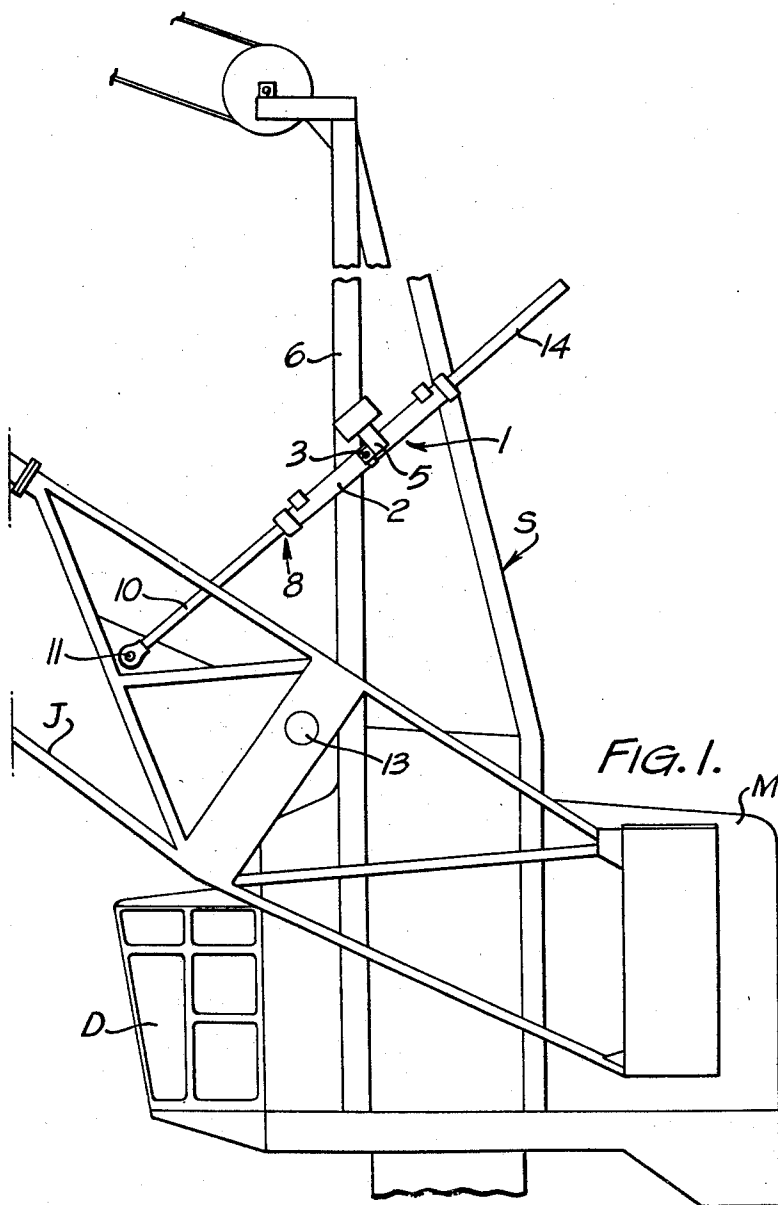


Filed June 30, 1960

FLUID OPERATED RAM

8 Sheets-Sheet 1



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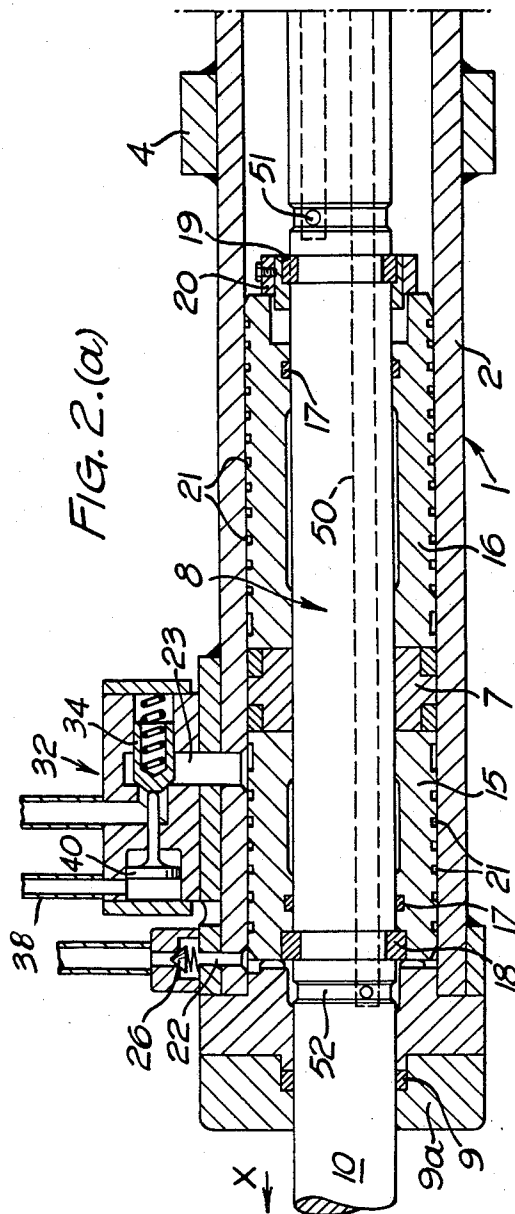
March 26, 1963

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FLUID OPERATED RAM

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Filed June 30, 1960

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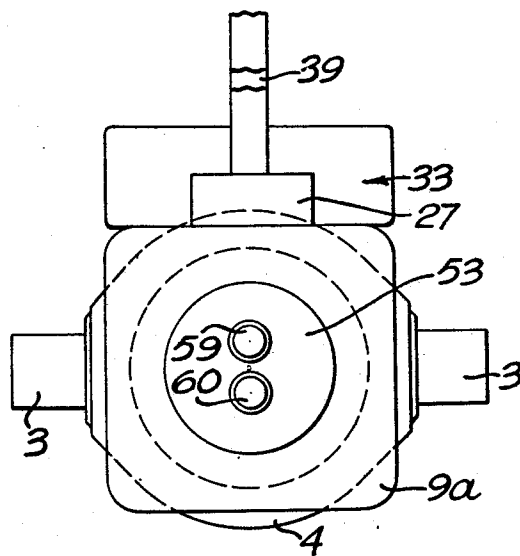


FIG. 3.

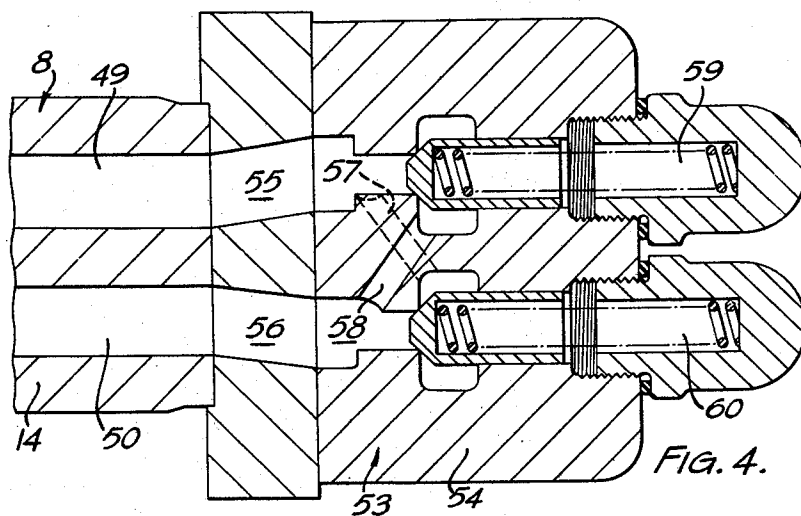


FIG. 4.

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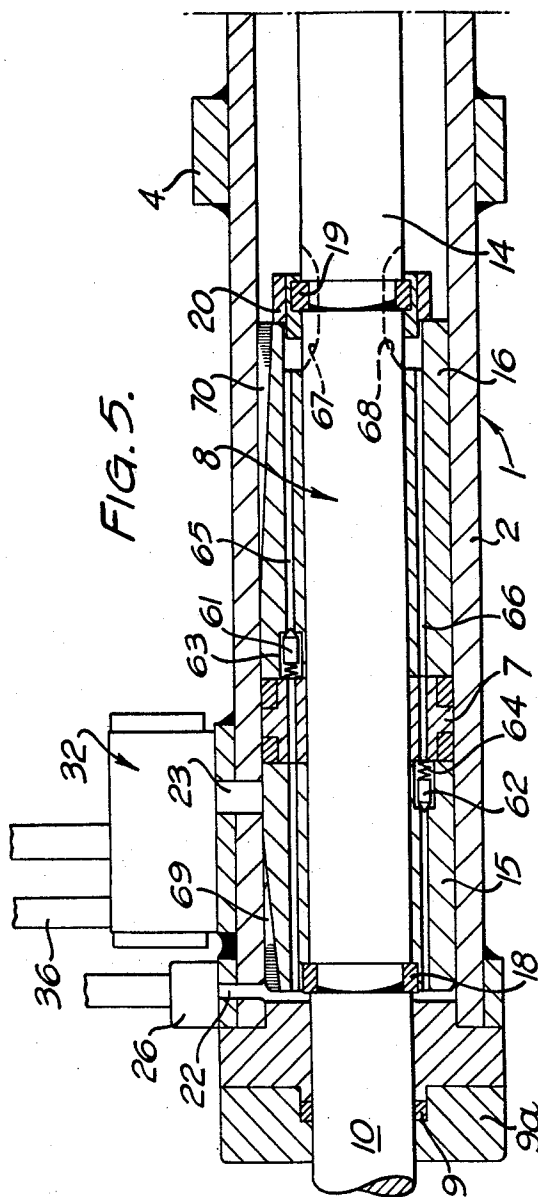
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3,082,746

FLUID OPERATED RAM

Filed June 30, 1960

8 Sheets-Sheet 5



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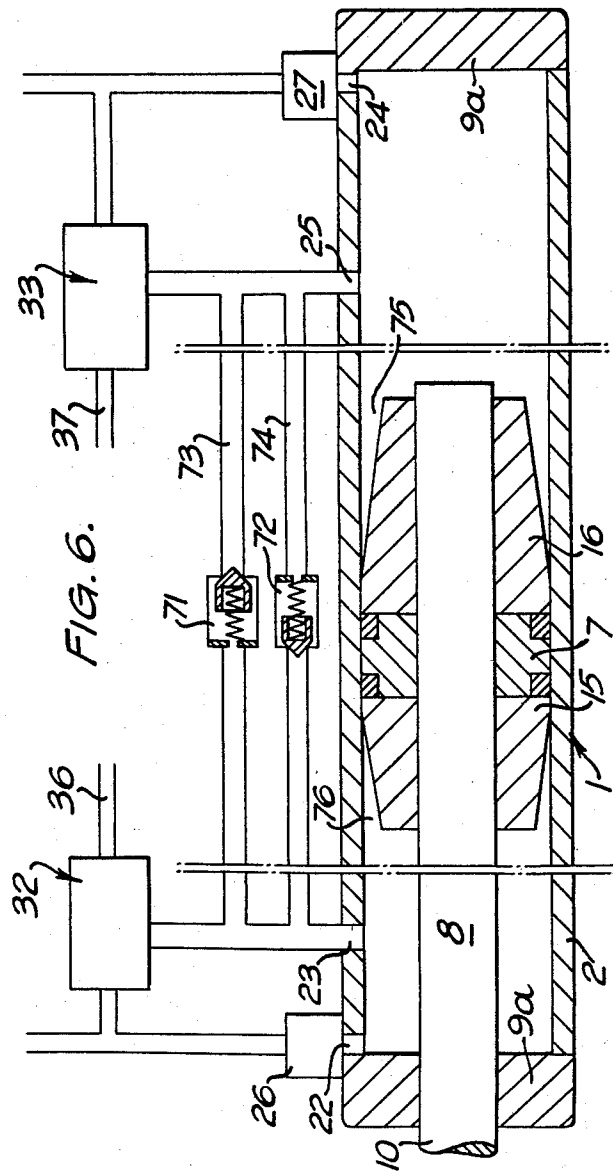
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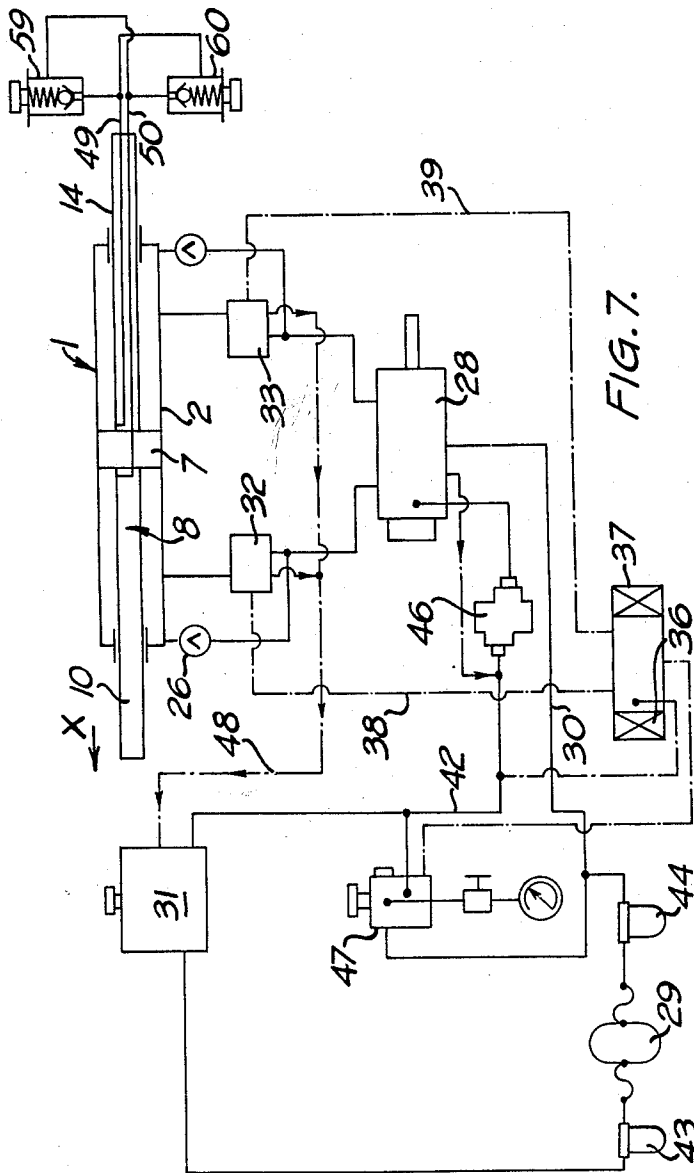


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FLUID OPERATED RAM

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FLUID OPERATED RAM

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3,082,746

FLUID OPERATED RAM

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Filed June 30, 1960, Ser. No. 39,835

Claims priority, application Great Britain June 30, 1959

7 Claims. (Cl. 121-46)

This invention relates to hydraulically or pneumatically operated rams and more particularly to means for decelerating the movement of the piston in such rams.

Double acting rams have many applications as a means of operating heavy machinery and mechanical equipment and it has been found that such rams are particularly suitable for use as a luffing mechanism for jib cranes of the level luffing type having a balanced jib since such a mechanism has numerous advantages compared with standard luffing gear.

It is among the objects of this invention to provide a double-acting ram, motive fluid to which is supplied from a fixed rate displacement pump which is continuously driven at substantially constant speed by an electric motor.

With such an arrangement it becomes necessary to introduce safety measures to ensure that if the operator should arrest the piston before it reaches either of its extreme positions, damage may not result due to the momentum of the load owing to his having to arrest its movement too suddenly. Like if at any time, the control lever should be moved too quickly from "stop" to "full speed" the sudden movement of the piston may similarly result in damage.

It is among the objects of the invention to provide decelerating means which are effective to prevent any sudden build-up of pressure in the cylinder of the ram caused by the momentum of the load to which the ram is connected.

It is a further object of the invention to provide decelerating means which can be adjusted externally of the ram and thus enabling the ram to be adjusted for use with varying loads without the necessity of dismantling the complete mechanism.

According to the invention there is provided a fluid operated double-acting ram including means for controlling automatically the acceleration and deceleration of the ram piston to effect smooth operation thereof at all times, which means comprise two pressure relief valves which are both in communication with both sides of the ram piston which valves in use are set, in whichever direction the piston may be travelling, to operate at a predetermined pressure differential to pass fluid from one working chamber to the other and thereby limit the acceleration or deceleration force which can be applied to the piston and thus also to the machinery on which the ram is mounted.

In a preferred construction the means for controlling deceleration of the piston consists of two spring actuated pressure relief valves mounted on the piston rod or within the ram piston, said valves being in communication by means of passage ways provided in the piston rod and/or in the piston with the working chambers on opposite sides of the piston, whereby in operation should the pressure differential in the working chambers exceed a predetermined value the relevant relief valve automatically comes into operation and allows liquid or air to pass from one working chamber to the other thereby limiting the accelerating or decelerating force which can be exerted on the ram and thus on the machinery on which the ram is mounted.

Thus it will be understood that in use, although the operator controls the variable speed of the piston, the

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pressure relief valve is operative to eliminate or substantially reduce overloads or jerky motions of the piston should the operator's control lever be brought rapidly into an operative or inoperative position.

According to the invention still further, the double-acting ram is provided with means which operate automatically to dampen the movement of the ram piston at or near completion of its stroke in either direction.

Such means preferably comprise a damping piston fitted on the piston rod on each side of the ram piston, the damping pistons, which may be formed by extensions of the main ram piston or by separate pistons on each side of it, being formed so as to permit of limited controlled leakage of the fluid through outlet ports provided in appropriate positions in the ram cylinder.

The invention is illustrated by way of example with reference to its use in a jib crane in the accompanying drawings in which,

FIGURE 1 is an elevation of part of a jib crane and showing the use of the ram according to the invention as a luffing mechanism,

FIGURES 2(a) and 2(b) collectively represent a longitudinal section through a double-acting ram according to the invention,

FIGURE 3 is an end elevation in the direction of the arrow III of FIGURE 2(b).

FIGURE 4 is a detailed section, on an enlarged scale, of the pressure relief valve assembly,

FIGURE 5 is a longitudinal section of part of a modified ram.

FIGURE 6 is a longitudinal section through a further modified ram,

FIGURE 7 is a schematic layout of the fluid circuit supplying the ram,

FIGURE 8 is a longitudinal section through a still further modified ram, and

FIGURE 9 is a detailed section, on an enlarged scale, of the pressure relief valve assembly of FIGURE 8.

Referring to FIGURE 1 of the drawings there is shown part of a travelling crane comprising a truck, on which is rotatably carried for slewing movements a superstructure S having a jib J. M is the machinery housing and D the driver's cabin. The superstructure includes a pintle tube (not shown) rotatably supported in the truck and is the subject of my co-pending application No. 39,834, filed June 30, 1960.

As shown in FIGURES 1 to 4 the invention as applied to the luffing mechanism of a crane comprises a single double-acting hydraulic ram 1 having a working cylinder 2, which is pivotally carried by means of trunnions 3 on a collar 4 fixed approximately centrally of cylinder 2 to horizontal bearings 5 mounted on a vertical strut 6 of the crane superstructure S. The cylinder 2 contains a ram piston 7 which is mounted on a piston rod 8, rod 8 extending through seals 9 provided in end closure members 9a at both ends of the cylinder. The working end 10 of the piston rod 8 is provided with a ball joint 11 by which it is connected to the jib J of the crane, the pivotal mounting of the jib being by means of a spindle 13 mounted in bearings on strut 6 of the superstructure S. The other end of the piston rod 8, hereinafter referred to as the dummy end 14 projects through the end of the cylinder and serves to increase the axial strength of the ram construction. In addition it will be understood that the provision of the dummy end 14 of the piston rod 8 provides a ram in which the effective areas on both sides of the piston are the same.

Mounted on the piston rod 8 on opposite sides of the ram piston 7 are damper pistons 15, 16 provided with sealing rings 17 to prevent leakage of oil from one end or working chamber of the cylinder to the other. The damper pistons 15, 16 together with the ram piston are

held in position on the piston rod by means of an annular key 18 at one end and by means of a similar key 19 co-operating with retaining rings 20 at the other end.

The outer diameters of damper pistons 15, 16 which extend co-axially with the cylinder 2, are slightly smaller than the bore of the cylinder to provide an annular passage, to allow the leakage of oil past the damper piston under certain operating conditions as hereinafter described. A series of annular grooves 21 are formed in the outer circumferential surface of each of the damper pistons 15, 16 to allow flow of oil around the pistons in the event of the pistons being off center.

In each working chamber are two ports 22, 23 and 24, 25, the ports 22 and 24 communicating with the extreme outer ends of the working chambers, while the ports 23 and 25 are spaced a short predetermined distance from the extreme outer ends so as to be covered respectively by the damper pistons 15 and 16 towards the ends of the strokes of the ram piston. For convenience the ports 22 and 24 will be referred to as the secondary ports and the ports 23 and 25 as the main ports.

The secondary ports 22 and 24 communicate through non-return valves 26, 27, which permit flow into but not out of the working chambers, respectively with two appropriate ports of a main directional control valve 28 (FIGURE 7), by which either of the ports can be connected, by the driver, to an oil supply line 30 (FIGURE 7) to which oil under pressure is supplied by a constantly driven pump 29 from an oil reservoir 31.

The main ports 23 and 25 are connected to the same ports of the main control valve 28 as their associated secondary ports 22 and 24, through pilot-operated non-return valves 32, 33 having spring loaded valve members 34, 35 which are remotely controlled by solenoid operated pilot valves 36, 37 (see FIGURE 7) acting through pilot lines 38, 39 and plungers 40, 41. Thus either one of the main ports 23, 25 can also be connected through the main control valve 28 to the source of oil under pressure while the other main port is connected through the control valve 28 to a return line 42 leading back to the reservoir 31.

In addition the main ports 23, 25 under the control of the pilot valves 36, 37 serve as exhaust ports for the oil.

The pump 29 is a fixed displacement pump, which is continuously driven at substantially constant speed by an electric motor and the oil circuit also includes a suction filter 43 and a micro-filter 44 for filtering the oil.

The speed and direction of the movement of the ram piston is controlled by the position of the driver's operating lever by which the setting of the main control valve 28 is controlled. A limiting valve 46 controls the flow on the exhaust side of the ram piston while a relief valve 47 serves to limit the pressure on the outlet side of the pump 29 and to by-pass any excess oil flow back to the reservoir 31. This valve is also designed to unload the pump when the directional valve 28 is in the central position and to by-pass the oil from the pump 29 back to the reservoir 31. Suitable seal drains 48 may also be provided.

The operation of the apparatus so far described is as follows:

Assuming the jib 12 is to be "luffed out" that is to say the ram piston and the piston rod are to be moved in the direction of the arrow X, the driver moves his operating lever to a position where the main control valve 28 connects the main port 25 and the secondary port 24 to the source of oil under pressure and also connects the main port 23, which is now serving as an exhaust port, to the return line 42. At the same time the pilot valve 36 occupies a position where it causes opening of the non-return valve member 34. Thus oil under pressure is delivered to one working chamber of the cylinder through the ports 24 and 25 while the oil in the other

working chamber is exhausted through the main port 23 and the ram piston therefore moves in the desired direction.

Moreover if and when the ram piston moves so far in the direction of arrow X that the damper piston 15 covers the main port 23, flow through the port 23 is restricted and the annular clearance between the damper piston and the cylinder only allows limited leakage of the oil through the main port 23. The back pressure thus produced on the exhaust side of the piston is utilised to decelerate the speed of the piston and thus the luffing movement of the jib (at any desired rate) should the piston be driven to the end of its stroke with the main control valve open. Thus the damping piston 15 serves to dampen the movement of the piston 7 during the last part of its stroke to effect smooth operation and to eliminate jarring, which would otherwise be liable to cause damage to the apparatus and to cause unnecessary and undesirable swinging of the load carried by the jib.

On the return stroke oil is admitted through the secondary port 22, which is not covered by the damper piston 15, and to a limited degree through the main port 23 which is covered by the piston at the same time oil from the exhaust chamber at the RH end of the cylinder passes out through the main port 25. After the damper piston passes the position of the main port 23 in the working chamber at LH end of the cylinder and therefore uncovers it, oil flows therethrough at a normal rate. As stated above the secondary ports 22, 24 are not essential and, if desired, ports 22 and 24 can be omitted and the oil passed into the cylinder through the main ports 23, 25 only. In this case the acceleration and the speed of the ram are lower in the first part of the stroke due to the restriction caused by the damping pistons.

Differential control of the decelerating action of the damping pistons may be obtained by variation in the axial length, cross-section and clearance of the damping pistons within the cylinder.

In the dummy end 14 of the piston rod 8 are two axial passageways 49 and 50. The inner end of the passageway 49 communicates through an annular groove 51 formed in the dummy end of the piston rod 8 with one of the working chambers of the cylinder but the inner end of the passageway 50 extends beyond the ram piston and communicates through an annular groove 52 with the other working chamber. Mounted on the free end of the dummy end 14 of the piston rod 8 is a valve assembly 53, which consists of a casing 54 having two bores 55, 56 which communicate respectively with the passageways 49 and 50. The bores 55, 56 and thus also the passageways 49, 50 are capable of being placed in communication with one another through openings 57, 58 which are under the control of spring loaded relief valves 59, 60 biased into a position where they normally close the ends of the passageways to prevent communication therebetween.

The valve 59 is arranged to open automatically to permit flow of oil from one of the working chambers to the other through the passage 49, the opening 58 and the passage 50 when the difference in pressure between the pressure in the first working chamber and that in the second chamber exceeds a predetermined value. Similarly the other valve 60 is arranged to open automatically when the difference in pressure between the pressure in the second working chamber and that in the first chamber exceeds the said value. The valves 59, 60 therefore determine the maximum pressure difference which can exist respectively in the two working chambers. It will be apparent therefore that irrespective of the manner in which the driver moves his control lever to operate the main control valve 28 to effect or to stop movement of the ram piston in either direction, the appropriate decelerator valve will determine the maximum force which can be applied to the ram piston, so that by

adjusting the spring pressure applied to the valves 59, 60 the maximum stresses which can be applied to the crane structure during acceleration or deceleration of the ram piston can be limited to those which are safe.

The relief valves 59, 60 it will be seen are mounted externally of the ram cylinder so that they are easily accessible for adjustment purposes.

Alternatively the passageways 49, 50 connecting the two working chambers can be formed by using a hollow piston rod or a piston rod, which is hollow for part of its length and which in each case has a pipe co-axially mounted therein so that the passage formed by the pipe communicates with the working chamber on one side of the piston, whereas the annular passage formed by the hollow piston rod communicates with the working chamber on the other side of the piston.

In the modified construction shown in FIGURE 5 spring loaded pressure relief valves 61, 62 are positioned internally of the ram cylinder, being arranged in openings 63, 64 provided respectively in the damper pistons 15, 16. The openings 63, 64 are in communication with both working chambers through passageways 65, 66 which extend axially through the ram piston 7 and the damper pistons 15, 16, the outer ends of the passageways 65, 66 adjacent the dummy end 14 of the piston rod 8 being arranged to open out into axially extending peripheral grooves 67, 68 provided in the piston rod 8 to complete communication with the working chamber on that side of the ram piston.

The relief valves 61, 62 operate in the same manner as the relief valves 59, 60 described with reference to FIGURES 2, 3 and 4 and determine the maximum pressure differences, which can exist respectively in the two working chambers.

Furthermore FIGURE 5 shows a modification of the means provided on the damping pistons 15, 16 for allowing limited controlled leakage of oil at the end of each stroke of the ram piston for damping or decelerating the force thereof.

In this modification the damping pistons 15, 16 are of generally cylindrical form and are provided respectively with tapered axially disposed peripheral grooves 69, 70 which permit limited flow of oil through the main ports 23, 25 at the appropriate time.

In the further modification shown in FIGURE 6 spring loaded pressure relief valves 71, 72 are mounted externally of the ram cylinder in external conduits provided for this purpose, the conduits opening at each end into the working chambers and are connected to the oil line serving the main ports 23, 25. In this case the pilot operated non-return valves 32, 33 may or may not be secured directly on the ram cylinder 2. Here again the relief valves 71, 72 operate in the same manner as that described with reference to FIGURES 2, 3 and 4.

In addition FIGURE 6 shows a further modification of the means provided for damping or decelerating the movement of the ram piston 7 at the end of each stroke. In this case the damping pistons are of tapered formation to provide tapered annular passages 75, 76 to allow limited controlled flow of the oil through the main ports 23, 25 at the appropriate time.

In the modified construction illustrated in FIGURES 8 and 9 the ram comprises a cylinder 77 having fluid ports 78, 79 in which cylinder is arranged a piston 80. The piston 80 is secured to a piston rod 81 which extends through one end only of the cylinder 77 and is adapted to be secured to a movable part of the equipment or machinery concerned whilst the cylinder 77 is arranged to be connected to a fixed part thereof.

Extending axially along the piston rod 81 are two passageways 82 and 83, the passageway 82 extending through the piston 80 to communicate with the working chamber on one side of the piston and the passage 83 extending to a position short of the piston 80 to communicate with

the working chamber on the other side of the piston. Mounted on the piston rod 81 at an intermediate position between the ends thereof is a valve assembly 84 which consists of a housing 85 provided with bores 86 and 87 which co-operate with the transverse bores 88 and 89 formed in the piston rod 81 and which bores serve to effect communication between the two passages 82, 83. Communication between the passage 82, through the bores 86, 88, and the passage 83 is under the control of a spring loaded pressure relief valve 90 which is mounted in an opening 91 provided in one side of the housing 85. Similarly communication between the passage 83, through the bores 87, 89, and the passage 82 is under the control of a spring loaded pressure relief valve 92 mounted in an opening 93 formed in the opposite side of the housing 85.

The relief valves 90, 92 of this construction are arranged to operate in the same manner as the relief valves 59, 60 described with reference to FIGURES 2, 3 and 4 and determine the maximum pressure difference which can exist respectively in the two working chambers.

It will be found that the hydraulic luffing mechanism of this invention, when used in conjunction with a suitable control circuit, ensures that in the event of any pipe failure the ram will either stop immediately or it will continue to move at slightly increased speed in the direction in which it is moving at the time of failure until it either reaches the end of its stroke, or until the driver's control lever is brought to the "off" position. After the ram has stopped, following upon a pipe failure, it cannot be restarted. The system is therefore completely "fail safe" as far as pipe failure is concerned.

With any of the damping arrangements, should the driver's control lever be brought suddenly to the "off" position when the damping pistons are inoperative, the subsequent deceleration of the jib will be governed entirely by the appropriate relief valve. However, with the alternative arrangement, in which the relief valves are mounted in connections external to the ram cylinder, under the above conditions the deceleration of the jib will be due to the oil passing first past the damping piston and then through the relief valve i.e. the two damping means will be acting in series.

Although the invention has been specifically described with reference to a luffing mechanism for a jib crane it is not limited to this particular use, thus it may for example, be used in other types of cranes, mechanical shovels or dumpers or any other mechanical equipment or machinery where controlled movement of the ram is necessary.

I claim:

1. A fluid operated double acting ram comprising a ram cylinder having fluid inlet and outlet ports communicating with the ends thereof, pilot operated valves controlling said ports, a ram piston mounted for axial movement within said cylinder, a piston rod carrying said piston and having an end extending through and beyond one end of said cylinder, and valve means carried by said projecting end of said piston rod and controlling communication between said ends of said cylinder to limit maximum differential pressures on opposite sides of said piston for controlling the maximum acceleration thereof.

2. A fluid operated double-acting ram comprising a ram cylinder having fluid inlet and outlet ports communicating with opposite ends thereof, pilot operated valves controlling said inlet and outlet ports, a ram piston mounted for axial movement within said cylinder, a piston rod carrying said piston and having its ends projecting through and beyond the ends of said cylinder, one end of said rod being a working end and the other a dummy end, valve means mounted on said dummy end for controlling automatically the acceleration and deceleration of said ram piston, said valve means comprising a first relief valve communicating with opposite ends of said cylinder to permit the flow of fluid from one such end to the

other, and a second relief valve communicating with said ends of said cylinder to provide for the flow of fluid in the opposite direction, and damping means associated with said piston for automatically effecting deceleration thereof at the end of each stroke in either direction, said damping means comprising a damping piston arranged at each end of said ram piston, said damping pistons limiting the leakage of fluid through said ports whereby said relief valves operate, when the pressure differential on opposite sides of said ram piston exceeds a predetermined value to control the movement of said ram piston and said damping pistons are arranged to control and dampen said ram piston at the end of a stroke in either direction.

3. A fluid operated ram as claimed in claim 2, in which said first and second relief valves are mounted on said piston rod externally of said ram cylinder, said piston rod having two axially bored passageways for effecting operative communication between said relief valves and said working chambers.

4. A fluid operated ram as claimed in claim 2, in which said damper pistons are provided of a diameter which is slightly less than that of the internal diameter of said ram cylinder so as to leave an annular passage for the passage of fluid.

5. A fluid operated ram as claimed in claim 2, in which said damper pistons are each formed with an axially extending groove in the periphery thereof for the passage of fluid.

6. A fluid operated valve as claimed in claim 2, in which said damper pistons are of tapered formation to provide tapered annular passages for the flow of fluid.

7. A fluid operated double acting ram comprising a ram cylinder having fluid inlet and outlet ports communicating with opposite ends thereof, pilot operated valves controlling said inlet and outlet ports, a ram piston mounted for axial movement within said cylinder, a piston rod carrying said piston and extending through opposite ends of said cylinder, one end of said piston rod being a working end and the other end being a dummy end, valve means carried by said dummy end of said piston rod wholly externally of said cylinder for controlling communication between said ends of said cylinder to limit maximum differential pressures in opposite sides of said piston for controlling the maximum acceleration thereof, and damping means for automatically effecting deceleration of said piston at the end of its stroke in either direction.

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