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HYDRAULIC ACTION DEVICES WITH INERTIA
INSENSITIVE SNUBBING CIRCUIT

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Fig. 1

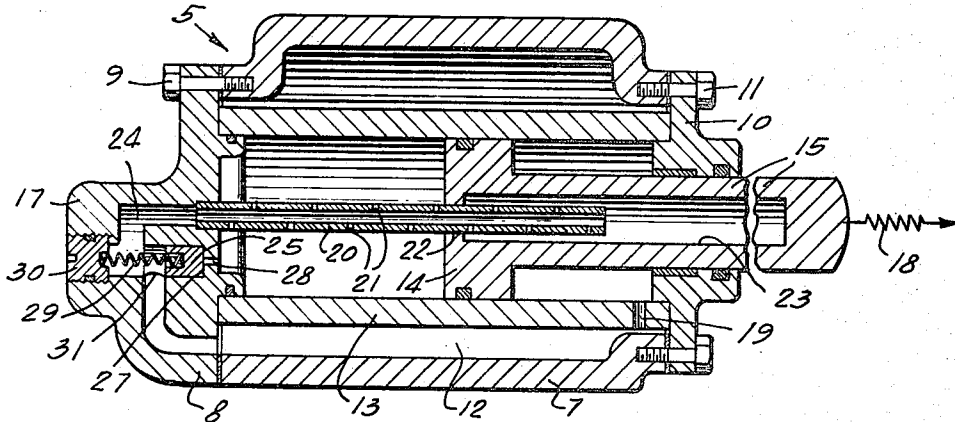
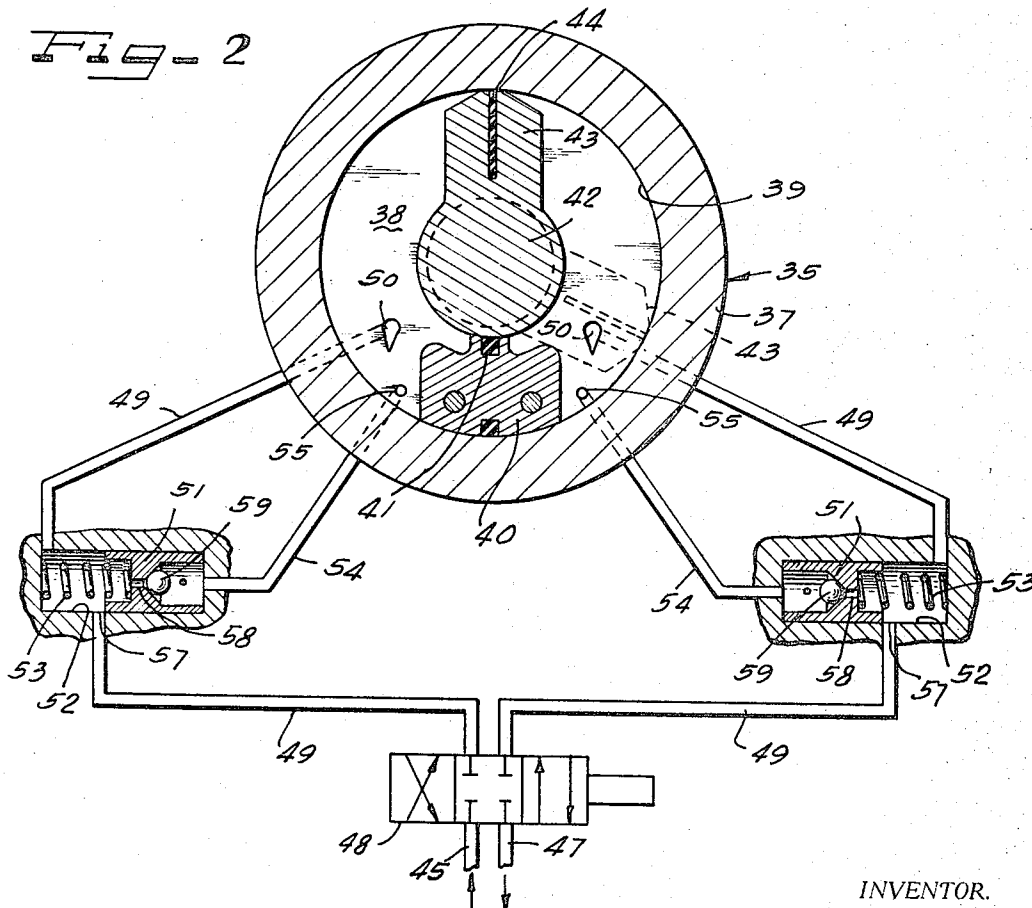


Fig. 2



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HYDRAULIC ACTION DEVICES WITH INERTIA INSENSITIVE SNUBBING CIRCUIT

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7 Claims. (Cl. 188—97)

ABSTRACT OF THE DISCLOSURE

A hydraulic action device such as a buffer, actuator, and the like, comprises means defining a working chamber from which hydraulic fluid is arranged to be displaced through a passage by a member such as a piston, wing-shaft vane, and the like operative under substantial load variables, and a valve is referenced directly to the working chamber independently of the passage to control the passage for effecting a substantially uniform rate of deceleration of the member irrespective of load, force or inertia.

The present application is a continuation of my application Ser. No. 523,426, filed Jan. 27, 1966, now abandoned.

This invention relates to improvements in hydraulic action devices on the order of shock absorbers, buffers, rotary actuators, and the like, and more particularly concerns inertia insensitive snubbing circuit means especially useful with such devices.

In the operation of hydraulic action devices of the type indicated, a serious problem has existed in respect to stopping variable inertia loads. Generally a compromise setting or adjustment has been established in the associated hydraulic circuitry to accommodate the mean inertia force, or at least the force predominantly encountered in the use of the device. Hence, in substantially higher inertias there is a strong tendency for the hydraulic stopping means to bottom out, whereas, if the inertia load is substantially lighter excessively high deceleration forces are encountered.

For example, in a hydraulic draft gear buffer for railroad cars designed to function efficiently under applied inertia force of 400,000 pounds substantially higher force results in a bottoming out and jarring reaction. At the other extreme a much lighter force such as where the associated railroad car is loaded with lightweight and possibly fragile lading, greatly excessive deceleration G forces would be encountered. Hence, at the opposite extremes severe lading damage can ensue. It will be understood, of course, that these evaluations assume the existence of substantially the same initial speed or velocity.

Similar difficulties are encountered in hydraulic actuators of the kind used on earth moving equipment such as the swing actuators on backhoes. If the hydraulic control circuitry is designed to stop the backhoe under an average inertia load condition, should the operator of the equipment inexpertly come into the stops with the boom fully extended and the bucket fully loaded, the hydraulic actuator generally will not stop it and the boom will ram into the solid stops with destructive force. On the other hand, if snubbing is made strong enough in the system to stop the boom under the worst condition, then when the boom is in close, or lightly loaded, the speed of operation of the backhoe will be severely limited near the ends of travel because of the high braking force exerted, resulting in excessively slow operation.

Accordingly, it is an important object of the present invention to provide in hydraulic action devices a new and improved inertia insensitive snubbing circuit in which snubbing will be in proportion to the inertia forces ex-

erted in order always to bring the load to rest at the same rate.

Another object of the invention is to provide a new and improved snubbing circuit for hydraulic action devices of the character indicated in which the load will be brought to rest from a predetermined speed at a constant G force irrespective of the amount of inertia in the load, such that if the inertia is high the snubbing pressure will be high and if the inertia is low the snubbing pressure will be low.

A further object of the invention is to provide new and improved buffing means affording the maximum efficiency at all times and capable of protecting the associated equipment from abuse by abnormal inertia load conditions, operator variation or inconsistency, and the like.

Another object of the invention is to provide new and improved inertia insensitive snubbing control means comprising novel control valve structure and pressure referencing means therefor.

Other objects, features and advantages of the present invention will be readily apparent from the following detailed description of certain preferred embodiments thereof taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a longitudinal sectional view through a hydraulic buffer of the reciprocable piston type, embodying features of the invention;

FIGURE 2 is a schematic illustration of a rotary hydraulic buffer or actuator including a snubbing circuit arrangement embodying features of the invention; and

FIGURE 3 is a schematic illustration of a rotary buffer or actuator with a modification of the novel inertia insensitive snubbing circuit features of the invention.

In one form, the invention is embodied in a representative reciprocable piston hydraulic shock absorbing buffer 5 (in FIG. 1) of the type useful in aircraft, missiles, radar antenna railroad car draft gear, and the like. It comprises a housing including a tubular body 7 having a front end closure cap 8 secured in closing relation thereto by means such as bolts 9 and a rear end closure cap or flange plate 10 secured thereto as by means of bolts 11. Within the housing body 7 is defined a reservoir 12 about a tubular working cylinder 13 which has its opposite ends mounted on the end closure members 8 and 10, respectively. Reciprocably slidably operable within the cylindrical working chamber defined by the cylinder 13 is a ram piston 14 having a smaller diameter piston rod projecting rearwardly concentrically thereon and in slidable bearing relation through the rear closure member 10 for operative engagement at its outer end portion with one of a pair of relatively movably related members of which the relative approaching movement must be buffed in service, the opposite of such members engaging with a front end buffer head 17 provided on the front end closure member 8. Means are desirably provided for normally biasing the piston 14 outwardly or into extended, protracted relation of the piston rod 15, the biasing means being represented by the symbol 18.

Normally the working cylinder is filled with hydraulic fluid which is adapted to be displaced in the reciprocations of the piston 14 into and from the reservoir 12. In this instance the area within the working cylinder chamber back of the piston 14 is in communication with the reservoir through a port 19 adjacent to the rear end of the cylinder. Buffing displacement of hydraulic fluid from that portion of the working chamber in front of the piston 14 is effected under progressively increasing resistance through a hydraulic fluid displacement control circuit passage including a metering tube 20 having orifices 21. At its front end the metering tube is anchored in the end closure member 8 concentric with the piston 14 into which the rear end portion of the metering tube extends

through a central bearing bore 22 in the piston opening into a clearance bore 23 within the piston rod 15 accommodating the metering tube as the piston progresses into the working cylinder. As a continuation of the control passage, a normally free flow duct 24 through the end closure 8 connects the front end of the metering tube 20 and the reservoir 12.

In order to provide constant snubbing deceleration irrespective of load, force or inertia during displacement of hydraulic fluid through the control passage, means are provided responsive directly to the pressure generated by the piston 14 in the portion of the working chamber forwardly thereof. To this end, a snubber valve 25 of the reciprocal plunger type is mounted in a blind end bore 27 opening forwardly in the end closure 8 in intersecting relation to the duct 24 and opening, in this instance, through the buffer head 17. At its inner, blind end, the bore 27 is spaced a limited distance from the inner face of the end closure member 8 exposed to the working chamber, and the adjacent end of the piston 25 is directly exposed or referenced to the pressure generated in the working chamber by the piston 14 through a pilot pressure control connection comprising an orifice 28. Normally the valve 25 is biased to leave the control passage open, and for this purpose a coiled compression spring 29 thrusts at one end against the end of the valve 25 which is exposed to the hydraulic pressure in the passage duct 24 and at its opposite end against an axially adjustable closure plug and velocity adjustment screw 30 which is threaded into a tapped outer end portion or extension of the bore 27. Through this arrangement, the control valve 25 is normally biased to clear a port 31, which leaves the control passage open, but is operable in response to hydraulic pressure from the working cylinder through the orifice 28 to move in opposition to the biasing spring 29 for throttling the passage orifice or port 31. Such throttling maintains a fixed differential across the valve 25 from one end to the other, since pressure is exerted against the duct end of the valve by way of the metering orifices 21 and against the chamber-connected end of the valve through the connecting orifice 28. Velocity adjustment is effected by means of the adjustment screw 30. At such velocity adjustment, affording an initial velocity constant, the buffer will always have a fixed stroke velocity curve, regardless of the amount of inertia striking either end of the buffer, and more particularly as an incident to movement of the members between which it is mounted toward one another.

Application of the principles of the present invention to a rotary vane type of hydraulic actuator 35 is represented in FIGURE 2. In such an actuator a tubular housing body 37 is closed at its opposite ends by means of end closure members 38 and defines a cylindrical working chamber 39 in which is fixedly mounted at least one abutment 40 having an inwardly projecting edge carrying a seal 41 which slidably engages the perimeter of a wing shaft 42 concentrically journaled in the actuator housing and having at least one vane 43 with its edges carrying a seal 44 slidably engaging the walls defining the working chamber 39 and cooperating with the abutment 40 to subdivide the working chamber into respective subchambers.

Control circuitry for the actuator 35 comprises a hydraulic pressure line or conduit 45 communicating with a suitable pressure source such as a pump, and a low pressure or return line or conduit 47. A conventional reciprocal control valve 48 is provided for selectively determining connection of the pressure and return lines 45 and 47 with respective hydraulic fluid displacement control circuit passages 49 connected at one end with the control valve and at their opposite ends with the respective working subchambers through an orifice 50 in each instance opening through one of the end closures 38 adjacent to the abutment 40 and in that portion of the subchamber toward which the vane 43 is driven in each respective

direction of oscillation in operation. In addition, each of the orifices 50 is so located and shaped that as the vane 43 approaches its respective limit at the abutment 40 the displacement orifice is progressively closed off for rapid deceleration of the wing shaft. A generally teardrop shape of each of the orifices 50 with its widest portion at the end toward which the vane approaches is desirable for progressive deceleration cutoff.

To assure constant snubbing deceleration irrespective of inertia, a reciprocable plunger valve 51 is mounted in a bore 52 which intersects the passage 49. Normally the valve 51 is biased toward one end of the bore 52 by means of a coiled compression spring 53 so as to leave the passage 49 open. At its end opposite the biasing spring 53, the valve 51 is referenced to the portion of the associated working subchamber toward which the actuator vane 43 generates pressure in operation, such reference being effected by pilot pressure connecting duct 54 which communicates with its subchamber through an orifice 55 located adjacent to the abutment 40 clear of the vane 43 and its adjacent terminal position, as indicated in dash outline in FIGURE 2. Through this arrangement, the snubbing valve 51 automatically controls an orifice or port 57 affording communication of the line 49 with the bore 52 responsive to vane generated pressure in the associated working subchamber in substantially the same manner as described in respect to the valve 25. Each of the valves 51 is provided with an orifice 58 therethrough controlled by a ball check valve 59 at its end referenced to the subchamber through the passage 54, whereby to enable the wing shaft vane 43 to be moved rapidly away from the abutment 40 when the adjacent deceleration metering orifice 50 is closed off by the wing shaft.

A further refinement of the inertia insensitive snubbing circuit is depicted in FIGURE 3 in respect to a rotary vane hydraulic actuator 60 including a housing 61 defining a cylindrical working chamber 62 closed at the opposite ends by respective end closures 63 and having mounted therein at least one fixed abutment 64 with an inner edge having a seal 65 and slidably cooperating with an oscillatable wing shaft 67 having a vane 68 with an edge provided with a seal 69 slidably engaging the walls defining the working chamber 62 and cooperating with the abutment 64 to divide the working chamber into subchambers. A hydraulic pressure supply line 70 and a return line 71 are connected through a conventional four-way plunger control valve 72 with the respective subchambers of the actuator through inertia insensitive snubbing circuit passages 73, each of which communicates with its subchamber through a respective port 74 in one of the end members 63 and having a pattern of communication orifices 75 which are adapted to be progressively closed as the vane 68 approaches the terminal limit of its stroke toward the abutment 64 in order to decelerate the wing shaft rapidly. Each of the circuit passages 73 has speed control valve means 77 including an adjustable orifice or throttle valve portion 77a and a one-way check valve portion 77b. For enabling rapid movement of the actuator vane 68 away from the abutment 64 even though the port 74 is fully covered, a respective orifice 78 located in the corner of the subchamber adjacent the abutment 64 clear of the vane in its terminal position affords communication with a duct 79 which is in communication through a one-way check valve 80 with the passage 73. Anti-cavitation or overrun preventing means are provided comprising a pair of cross-over relief valves 81 which interconnect the two subchambers in order to prevent excessive pressure being developed in the actuator in the event the control valve 72 is abruptly centered when the actuator is moving at maximum speed. These valves 81 are connected across the ducts 79 and are biased in respective opposition to the direction of pressure movement of the hydraulic fluid from the respective ducts and responsive to predetermined pressure to throttle passage of hydraulic fluid through these valves respectively. As pressure builds up in the respective

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subchambers incident to closing of the orifices 75 in the terminal portion of the vane stroke, a plunger type throttle valve 82 in a bore 83 intersecting the passage 73 through which hydraulic fluid from the pressure line 70 is being delivered is pressurized through a branch 84 from the duct 79. This causes the pressurized valve 82 to move in opposition to a normally biasing coiled compression spring 85 to throttle a port 87 in the passage 73 which is in communication with the pressure line 70.

To provide constant snubbing deceleration irrespective of inertia, a plunger valve 88 mounted in the opposite end portion of the bore 83, and normally biased by the spring 85 to leave a port 89 in the associated passage 73 open, is referenced directly to its associated subchamber through a branch 90 leading from the duct 79 in its circuit. Since the biasing spring 85 bottoms under biasing compression oppositely against the companion inlet cutoff valve 82 and snubbing valve 88, these valves serve automatically to load the spring toward the opposite valve under respective pressure fluid thrust, thus attaining automatic biasing control in operation. Otherwise, functioning of the snubbing valve 88 is substantially the same as described for the snubbing valve 25 of FIGURE 1 and the snubbing valve 51 of FIGURE 2.

In all forms of the invention, an important feature resides in affording maximum efficiency in operation of the hydraulic action device, protecting the equipment from the inevitable abuses, extraordinary inertia loads either above or below the normal range, variations or inconsistencies in operator's handling of the equipment, etc.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. A hydraulic action device such as a buffer, actuator, and the like, comprising:

means defining a working chamber having hydraulic fluid therein;

means relatively movably operative through a substantial working stroke in said working chamber under likelihood of substantial load variables and in said stroke generating hydraulic pressure in at least a portion of the chamber;

means providing a hydraulic fluid displacement control circuit passage connected to said portion of the chamber for fluid driven from said portion of the chamber by the pressure generated in said working stroke by said movable means and including orifice means the effective flow area of which is progressively closed off by said movable means at least during the last part of said working stroke to effect snubbing deceleration of said relative movement and resulting in substantial increase in said hydraulic pressure; and

means directly referenced to said portion of the chamber independently of said passage and responsive to said increase in pressure to throttle and control said passage for effecting a substantially uniform rate of deceleration of said movable means irrespective of load, force or inertia.

2. A device as defined in claim 1, in which said directly referenced throttle and control means comprise an orifice

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leading from said portion of the chamber, and the effective flow area of said orifice means being substantially greater than the effective flow area of said orifice so that until said substantial increase in pressure the directly referenced throttle and control means remain substantially inactive.

3. A device as defined in claim 1 in which said directly responsive means comprise a snubber valve directly referenced to said portion of the chamber through a pilot pressure control connection independent of said passage and operative to control hydraulic fluid flow through said passage.

4. A device as defined in claim 3, in which said passage includes an orifice and said valve comprises a plunger operable in intersecting relation to said passage and normal to the axis of and across said orifice, and a spring normally biases the plunger from the orifice to leave the passage open.

5. A device as defined in claim 4, including means for adjusting the biasing pressure of said spring.

6. A device as defined in claim 2, in which said means defining a working chamber include a housing having therein a cylinder providing the working chamber and closed at opposite ends by closure members, and include a reservoir, said relatively movable means comprising a piston reciprocally operable in said cylinder and having a stem projecting through and beyond one of said closure members with the piston opposing the remaining closure member and therewith defining said portion of the working chamber, said passage connecting said portion of the chamber and said reservoir through and remaining closure member and in part extending generally transversely to the cylinder and piston axis, and said snubber valve being mounted in said remaining closure member between said part of the passage and said portion of the chamber and operable in the same axial direction as said cylinder and piston axis and said pilot pressure control connection extending through said remaining closure member between said portion of the chamber and said valve and comprising an orifice having its axis in the same direction.

7. A device as defined in claim 6, in which said remaining closure member has a blind end bore intersecting said passage with its axis in said direction and having its blind end spaced a short distance from the inner end of said remaining closure member, and valve comprising a plunger reciprocally mounted in said bore, a compression spring normally biasing said valve into clearance relation to said passage and toward said blind end, and said pilot pressure referencing orifice extending between said blind end and said inner end and communicating with said portion of the chamber.

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G. E. HALVOSA, *Primary Examiner*.

U.S. Cl. X.R.

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