HYDRAULIC JACK STROKE CUSHIONING MEANS

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ABSTRACT
A hydraulic jack is provided with means to cushion the piston and rod assembly at the end of its stroke. The cushioning means comprises a pair of resiliently supported sleeves, one placed on each side of the piston, that cooperate with respective bores in the housing of the jack to serve to progressively restrict the flow of fluid to an exhaust port as the piston nears the end of its stroke. The resilient mounting of the sleeves, comprising annular elastomeric seals, permits limited radial movement thereof with respect to the piston to compensate for any eccentricity of the bores relative to the piston.

12 Claims, 6 Drawing Figures
HYDRAULIC JACK STROKE CUSHIONING MEANS

BACKGROUND OF THE INVENTION

The present invention relates to hydraulic jacks having means to cushion the piston and rod assembly at the end of its stroke and pertains more particularly to the elimination of the concentricity and sealing problems between several components making up the cushioning means.

In most hydraulically actuated implements, it is necessary that the piston and rod assembly travel at a high rate of speed in order to achieve efficient operation. In such high speed implements, it is necessary that a large amount of inertial energy be absorbed by the housing of the jack as the piston and rod assembly comes into contact with the end of the housing. The high forces developed can result in considerable damage to the hydraulic jack structure. Many proposals have been made for alleviation of the problem but most prior art designs, however, are excessively complicated and expensive to manufacture, particularly in the area of providing concentricity between the several components of the cushioning means.

SUMMARY AND OBJECTS OF THE INVENTION

The primary object of the present invention is to provide a hydraulic jack that overcomes the above disadvantages of the prior art.

Another object of the present invention is to provide a hydraulic jack that employs a simple, inexpensive and effective means for cushioning the stroke of the piston and rod assembly.

A further and related object is to provide a stroke cushioning means for hydraulic jacks wherein at least one cushioning sleeve is carried by the piston to engage a bore in the jack housing to restrict flow therefrom. The sleeve is supported on the piston by an annular elastomeric seal providing the dual function of permitting limited radial movement of the sleeve to compensate for any eccentricity of the bore relative to the piston and cushioning sleeve support and of affording a fluid tight seal thereat.

In accordance with the present invention, a hydraulic jack is cushioned by restricting the fluid being expelled from the bore of the jack. This is accomplished by sleeve and bore combinations that restrict the exhaust port prior to contact of the piston and rod assembly with the end of the jack.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects of this invention will become apparent from the following description and accompanying drawings wherein:

FIG. 1 is a side elevational view of a machine equipped with one or more hydraulic jacks;
FIG. 2 is a fragmentary cross-sectional view of the head end section of a hydraulic jack;
FIG. 3 is a fragmentary cross-sectional view of the rod end section of a hydraulic jack;
FIG. 4 is a partial cross-sectional view taken along the lines of IV—IV of FIG. 2;
FIG. 5 is a partial cross-sectional view taken along lines V—V of FIG. 3; and
FIG. 6 is an enlarged cross-sectional view of a seal ring employed in the hydraulic jack.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and more particularly to FIG. 1, there is illustrated a machine employing several hydraulic jacks to manipulate the implements mounted on a machine. A jack 10, for example, is used to manipulate a stick 12, relative to a boom 14 of an excavator machine, shown generally at 16. The rod of the hydraulic jack is fastened to the stick by a pin joint 18, and the head end of the jack is secured to the boom by a pin joint 20. The jack is activated through a conventional control valve 22, which is manipulated by a control handle in the operator station through a mechanical linkage (not shown). A pump 24 is utilized to supply the fluid under pressure necessary to operate the jack, through control valve 22. A conventional relief valve 26 is located in the circuitry to protect against unduly high circuit pressures.

When jack 10 is retracted, stick 12 and a bucket 28 move away from machine 16 and fluid is directed to the jack from control valve 22 through a line 30. Fluid being expelled from the head end of the jack is returned to a tank 31 by a line 32, control valve 22 and a line 34. Whenever the jack is extended, swinging the stick and bucket toward the machine, fluid is directed to the jack through line 32 and fluid expelled from the rod end of the jack is returned to the tank by line 30, control valve 22, and line 34.

Due to the weight of stick 12 and bucket 28, rapid movement thereof develops a considerable amount of inertial energy that is transmitted to the piston and rod assembly of jack 10. The forces created by the inertial energy must be absorbed as the piston and rod assembly reaches the end of its stroke and contacts a stop in the jack housing. In some instances the forces created can cause structural damage to the components of the jack. For that reason it is desirable to have some type of cushioning means absorb most of the force prior to the time that the piston and rod assembly contacts its stop.

The head end portion of hydraulic jack 10 is illustrated in FIG. 2. A housing 36 thereof includes a suitable extension 38 for anchoring the jack to boom 14 by pin joint 20. A port 40 in the housing communicates with line 32 to communicate fluid into or out of an expandable actuating chamber 42 defined by the end wall section of the housing and a piston and rod assembly comprising a piston 44 and an elongate rod 46 reciprocably mounted in the housing for movement along the longitudinal axis thereof. Port 40 is in communication with chamber 42 via a cylindrical bore 48 formed in the end wall of the housing, the bore being substantially coaxial with respect to piston 44.

The head end cushioning means comprises a metallic cylindrical sleeve or ring 50 solely mounted on a cylindrical spacer 52, forming a cylindrical extension of rod 46, by an annular elastomeric combined sealing and centering means, shown in the form of a seal ring 54. Radial spacer 52 and an axial spacer 56 are secured in an axial relationship by a cap screw 58. Spacer or stop ring 56 further serves to enlarge the contact area of the piston and rod assembly that contacts cooperating stop means 59 formed internally on housing 36. Seal ring 54 serves two functions in that it allows limited radial floating movements of sleeve 50 for piloting the sleeve into bore 48, as described hereinafter, and prevents...
passage of fluid between the sleeve and spacer 52 in one direction.

Ring 54 is disposed in a groove 53 in sleeve 50 and preferably comprises an approximate U-shaped cross-section. An inner lip 55 of ring 54 extends radially inwardly and contacts the outside diameter of spacer 52 to function like a check valve in that fluid can flow between sleeve 50 and spacer 52 in a direction toward expandable chamber 42, but cannot flow in the opposite direction. FIG. 6 more clearly illustrates the ring in its relaxed condition prior to installation (phantom lines) and its compressed installed condition (solid lines).

During retraction of the jack, piston 44 and rod 46 will move toward the left in FIG. 2 to expel fluid from chamber 42, through the bore 48, port 40 and line 32. As the piston and rod assembly approaches the end of the stroke, sleeve 50 will enter into telescopic relationship with bore 48. Initial piloting of sleeve 50 will be affected by the flow of fluid past the end of sleeve 50 into bore 48. Since ring 54 will allow slight radial movements of the sleeve, the sleeve will accurately and automatically self-center itself into the bore. The sleeve is preferably constructed with a stepped-down outside diameter to provide restricted passage means comprising a smaller diametral first end portion 60 arranged to enter bore 48 first to provide gradual restriction to the flow of fluid from chamber 42. Subsequently, a larger diametral second end portion 62 of the sleeve enters the bore and further gradually restricts or governs the flow of fluid out of the chamber. A much closer tolerance can be maintained between portion 62 and the bore because of the piloting action of smaller portion 60 with the bore.

Restriction or governing of the flow out of chamber 42, as the piston and rod assembly reaches the end of its stroke, will cushion the stroke in the following manner. The restriction will cause a rise in the pressure in chamber 42 such that it will approach the pressure of the actuating fluid being directed to the other side of piston 44. As a result, the actuating fluid pressure will also increase until the setting of relief valve 26 is exceeded, at which time the relief valve will open and vent the actuating fluid to tank 31 through a line 64 (FIG. 1). Venting of the pump output allows the movement of the piston to be slowed by absorption of inertial energy of the moving components in the pressure generated in chamber 42 by the restriction to flow therewith. Absorption of the inertial energy of the moving components hydraulically, substantially reduces or eliminates shocks and stresses which would otherwise be imparted to the jack as a result of high speed contact of the piston with the housing.

The cushioning means employed on the rod end of the jack, illustrated in FIG. 3, is somewhat different in construction than that used for the head end. Although the configuration used could be the same for both applications, the volume of fluid expelled from a rod end expandable actuating chamber 66 is less than the volume expelled from the head end chamber 42. For that reason the FIG. 3 cushioning means embodiment is more suitable for use as a cushioning means at the rod end of the jack.

The rod end of jack 10 has a closure or end cap 68 secured to housing 36 in a conventional manner, such as by cap screws or by welding. Rod 46 passes through a bore 70 formed through the end cap and fluid is prevented from leaking therepast by means of a conventional seal 71. When the jack is extended, the piston and rod assembly moves toward the right to its FIG. 3 position.

Fluid is expelled from chamber 66 and sequentially through a bore 72, a port 74, both formed in end cap 68, and line 30. The rod end cushioning means comprises a sleeve 76 mounted in an annular recess formed in rod 46 solely by an annular elastomeric combined sealing and centering means or seal ring 78, similar in construction to ring 54 (FIG. 6). The seal ring serves the dual function of piloting sleeve 76 as it starts to enter bore 72 and of preventing leakage of fluid between the sleeve and rod.

Since the rod is accurately piloted into end cap 68 and since the sleeve 76 is resiliently supported on the rod by the seal ring 78, a close tolerance between the OD of the sleeve and the ID of bore 72 can be maintained.

As the sleeve telescopically enters bore 72, fluid flow out of chamber 66 effects a piloting action and the sleeve will be accurately positioned therein since it can move radially due to the resilient nature of elastomeric seal ring 78. Once the sleeve enters the bore, fluid flow out of chamber 66 is restricted almost entirely by restricted passage means shown in the form of tapered slots or grooves 80 formed on the OD of the sleeve. The slots are tapered so that as the sleeve moves into the bore, the flow is increasingly restricted until piston 44 contacts a stop 82 formed on end cap 68.

As the flow out of chamber 66 is gradually restricted, pressure therein will rise to a level sufficient to cause an increase in the pressure in the chamber 42 at the opposite end of the jack. Again, as the head end pressure reaches relief valve setting, actuating flow will be dumped to tank and rapidly slow the rightward movement and provide the desired cushioning effect.

By way of example, a pump flow of 131 gpm into the rod end of a jack containing a 7-inch diameter piston secured to a 4%-inch diameter rod would, during maximum retraction acceleration (121.5 feet per minute), cause a flow of 242gpm out of the head end chamber 42 of the jack. Conversely, when a pump flow of 131 gpm is directed to the head end of the jack, maximum extension acceleration (65 feet per minute) causes a flow of 70.6 gpm out of rod end chamber 66 of the jack. Again, the flow rate is dependent on the difference in volume between the two chambers of the hydraulic jack. As may be expected, governing or restriction of the fluid flow out of the rod end chamber is more critical than governing the much larger flow being expelled from the head end chamber of the jack.

What is claimed is:

1. A fluid actuated hydraulic jack disposed on a longitudinal axis thereof and comprising a housing;

a piston assembly, including a rod and attached piston, reciprocally mounted in said housing for movement along said axis and defining at least one expandable actuating chamber therewith, at least one passage means defined in said housing and terminating at an annular bore communicating directly with said actuating chamber for normally permitting substantially unrestricted fluid flow
through said passage means upon actuation of said jack, and
at least one cushioning means attached to said rod on
a side of said piston and disposed in axial align-
ment with said bore for closing said bore upon
movement of said piston assembly theretowards,
said cushioning means comprising,
a cylindrical sleeve having an inside diameter larger
than the outside diameter of said rod,
annular elastomeric combined sealing and centering
means solely mounting said sleeve on said rod for
permitting limited radial floating movements of
said sleeve relative to said rod, transversely on said
axis, and
restricted passage means defined between said bore
and said sleeve for gradually restricting fluid flow
therebetween upon progressive, axial movement
of a first end of said sleeve into said bore, said
restricted passage means comprising means
formed on the periphery of said sleeve and
cooperating with said bore to provide a larger flow
area at a first end of said sleeve than at a second,
opposite end thereof.

2. The hydraulic jack of claim 1 wherein one of said
cushioning means is mounted on said rod on each side
of said piston, said piston and housing defining two co-
axially disposed expansible actuating chambers in said
jack separated by said piston.

3. The hydraulic jack of claim 1 wherein the outside
diameter of the first end of said sleeve is less than the
diameter of the second end thereof to define said
restricted passage means with said bore.

4. The hydraulic jack of claim 1 wherein said
restricted passage means comprises at least one tapered
groove formed on the periphery of said sleeve and
disposed in axial alignment with respect to the longitudi-
 nal axis of said jack.

5. The hydraulic jack of claim 1 wherein said rod
comprises an axially aligned cylindrical extension at-
tached to an end thereof, said sleeve mounted on said
extension, a circumferentially extending groove formed
internally on said sleeve and having said combined seal-
ing and centering means disposed therein for solely
mounting said sleeve on said extension.

6. The hydraulic jack of claim 1 wherein said housing
comprises an end cap attached to an end thereof, said
rod extending through a bore formed in said end cap
and said passage means formed in said end cap.

7. The invention of claim 1 wherein said rod has an
axially extending annular recess formed on the
periphery thereof terminating at one end in an annular
shoulder portion, said sleeve mounted in said recess
between said shoulder portion and said piston.

8. The hydraulic jack of claim 1 wherein said com-
bined sealing and centering means constitutes a seal
ring, having an approximate U-shaped cross-section,
constructed and positioned for permitting pressurized
fluid flow only in an axial direction from said passage
means to said expansible actuating chamber.

9. The hydraulic jack of claim 1 wherein said seal
ring comprises a body portion and at least one flexible
lip means normally circumferentially contacting outer
surface portions of said rod, said flexible lip means ex-
tending generally toward said expansible chamber to
prevent pressurized fluid flow from said expansible
chamber to said passage means but to permit pres-
surized fluid flow from said passage means to said ex-
panible chamber.

10. A fluid actuated hydraulic jack disposed on a lon-
gitudinal axis thereof and comprising
a housing,
a piston assembly, including a rod and attached
piston, reciprocally mounted in said housing for
movement along said axis and defining at least one
expansible actuating chamber therewith,
at least one passage means defined in said housing
and terminating at an annular bore communicating
directly with said actuating chamber for normally
permitting substantially unrestricted fluid flow
through said passage means upon actuation of said
jack, and
at least one cushioning means attached to said rod on
a side of said piston and disposed in axial align-
ment with said bore for closing said bore upon
movement of said piston assembly theretowards,
said cushioning means comprising,
a cylindrical sleeve having an inside diameter larger
than the outside diameter of said rod, and
annular elastomeric combined sealing and centering
means solely mounting said sleeve on said rod for
permitting limited radial floating movements of
said sleeve relative to said rod, transversely on said
axis,
said seal comprising a body portion and at least one flexible lip means normally circumferentially contacting outer surface portions of said rod, said flexible lip means extending generally toward said expandible chamber to prevent pressurized fluid flow from said expandible chamber to said passage means but to permit pressurized fluid flow from said passage means to said expandible chamber.

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