

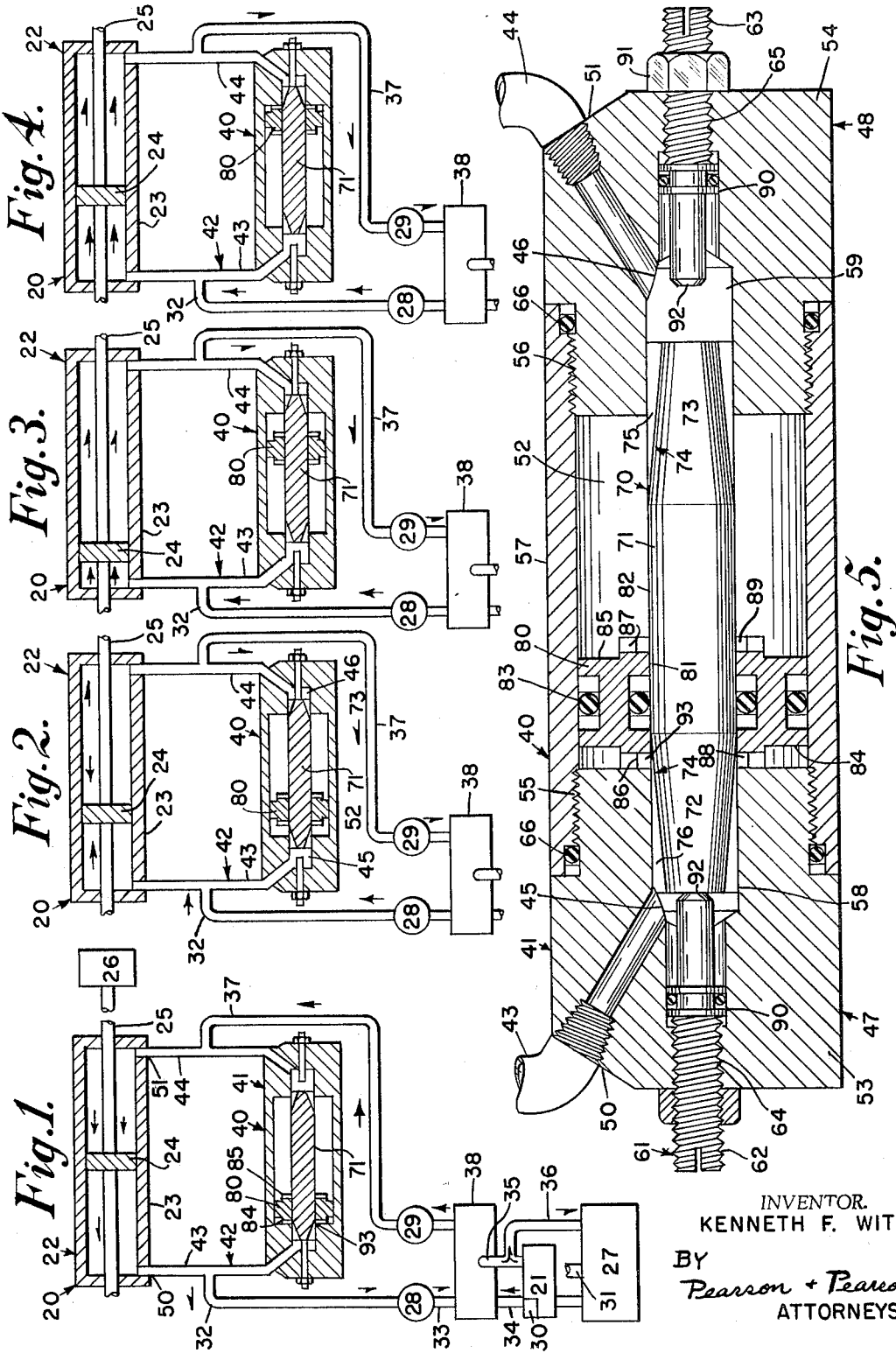
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HYDRAULIC CUSHION ASSEMBLY

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HYDRAULIC CUSHION ASSEMBLY

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9 Claims. (Cl. 91—35)

This invention relates to a remote hydraulic cushion assembly for reducing shock in a closed, hydraulic system having a double acting cylinder, a pump and flow reversal means.

In conventional hydraulic systems of this type, it has been proposed to provide resilient spring, or air cushion means, to take up shock when the incompressible hydraulic fluid filling the system is suddenly stopped by a shut-off valve, or reversed in its path by conventional valving. However, such expandable or compressible resilient compensators or accumulators tend to defeat the purpose of liquid systems in achieving accurate control of the work.

Therefore, the work cylinders of some such systems, have sometimes been equipped with a hydraulic cushion to reduce the shock of instantly stopping a fast moving load against the end of the work cylinder. Such devices usually trap the hydraulic fluid at each opposite end of its stroke, directing the trapped fluid through a small orifice to create back pressure and decelerate the piston near the opposite ends of the cylinder.

However, there are many hydraulic systems in use which have non-cushion cylinders and the cushion cylinders, now in use, cushion only the opposite ends of the stroke, although shock occurs in the system when the piston is stopped, or reversed, at any location along the work cylinder.

It is the principal object of this invention to provide a hydraulic cushion in a closed, incompressible hydraulic system, remote from the work cylinder, but arranged to cushion, or dampen, the movement of the work piston when flow is stopped, or reversed, with the work piston at any location along the work cylinder.

Another object of the invention is to provide such a remote, hydraulic cushion with a double acting valve and floating piston such that the piston creates instantaneous initial back pressure on the work piston when flow is reversed and the back pressure is gradually diminished by the valve.

A further object of the invention is to provide a remote hydraulic cushion having double acting throttle valve means and a floating piston for creating back pressure, the orifices of the throttle valve means being adjustable in cross sectional area to adjust the back pressure.

Still another object of the invention is to provide a hydraulic cushion assembly having a cylindrical valve rod with, tapered, grooved ends cooperable with end bores to form orifices of variable cross section whereby movement of each rod end into its bore progressively diminishes flow while the corresponding movement of the other rod end out of its bore progressively increases flow.

A still further object of the invention is to provide a closed, substantially incompressible, reversible hydraulic system with a double acting hydraulic cushion assembly connected in parallelism with the work cylinder of the system, the piston and throttle valves of the assembly gradually decelerating the piston of the work cylinder upon any stoppage, or direction change, of the oil to reduce shock in the system.

Other objects and advantages of the invention will be apparent from the claims, the description of the drawing and from the drawing in which:

FIGURES 1 to 4 are diagrammatic views in half section of a hydraulic system containing the remote cushion of the

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invention, and illustrating stages of the operation of the system.

FIGURE 5 is an enlarged side elevation, in half section of the hydraulic cushion assembly.

As shown in the drawing, the closed hydraulic system 20, includes a source of hydraulic fluid under pressure, such as the positive displacement, constant delivery hydraulic pump 21, and the double acting cylinder and piston motor 22, the cylinder 23 thereof being designated the work cylinder and the piston 24 thereof being designated the work piston. The work piston 24 has the usual piston rod 25, shown as being connected to a load 26 upon which it is to perform work, and the work piston 24 is capable of exerting thrust in both axial directions in the conventional manner. The system 20 also includes the conventional fluid reservoir 27, the conventional flow control valves 28 and 29 of the variable orifice type for regulating the speed of travel of piston 24 and the hydraulic conduits 32, 33, 34, 35, 36 and 37 all arranged in the conventional manner.

The system 20 also includes control mechanism 38, in the form of a four way, three position valve, one position advancing the rod 25, one position retracting the rod 25, and one position being neutral with all ports blocked to hold the rod 25 stationary. The pump 21, in the drawing, is of the unidirectional flow type, changes in direction being accomplished by the means 38, but the system illustrated is exemplary only and not intended to limit the invention to any particular type, or location, of the control mechanism.

The double acting cylinder 23 is of the non-cushion type and there are no energy accumulators or compressible shock absorbers in the system 20, since it is in such an incompressible system that the invention is particularly useful.

The pump 21 includes a conventional pressure relief valve 30 and the reservoir 27 includes a conventional air vent 31 to the atmosphere.

The remote hydraulic cushion assembly 40 comprises the double acting cushion cylinder 41, which is connected into the system 20, by hydraulic conduit means 42 consisting of conduits 43 and 44 and the ports 45 and 46 at each opposite end 47 and 48 of the cylinder. The double acting cylinder 41 is thus mounted in parallelism with the work cylinder 23 so that the end 47 of cylinder 41 is connected to the corresponding end 50 of cylinder 23 and the other end 48 of cylinder 41 is connected to the corresponding end 51 of cylinder 23. If the cylinder 41, were merely an open passage, it would constitute a bypass around the cylinder 23 and piston 24 so that back pressure would substantially equal forward pressure on piston 24 and any effective work by the piston would depend on the relative cross sectional areas of the parts.

However, cylinder 41 is not such an open passage and is provided with a centrally disposed, axially extending piston chamber 52 of predetermined length and diameter, the diameter being for example, about one third the diameter of the work cylinder. Conveniently, each end 47 and 48 of cylinder 41 is identical and consists of an end cap 53 or 54 threadedly connected at 55 and 56 to a cylindrical shell 57 and each end cap includes a cylindrical axial bore 58 or 59. Each bore 58 or 59 is closed at the outside end there being adjusting means 61 in the form of an adjusting screw 62 or 63 threaded at 64 or 65 in the end cap for a purpose to be described hereinafter. The inside end of each bore 58 or 59 opens into the piston chamber 52 and connects one end of the chamber with the adjacent port. Suitable O ring, or other type seals, 66 are provided to make the cylinder a fluid tight unitary assembly.

Throttle valve means 70 is provided consisting of the double acting, cylindrical, valve rod 71 which extends

axially of the cylinder 41 in the piston chamber 52 with each opposite end 72 or 73 thereof axially slidable in one of the cylindrical bores 58 or 59. Orifice forming means 74 at each opposite end 72 or 73 of valve rod 71 includes an annular series of tapered grooves such as 75 or 76, each groove being deep at the outside end of the rod so that in cooperation with the bore, the fluid orifices are of maximum cross section when the rod end is out of the bore and gradually diminish in cross section as the rod end moves into the bore.

A cushion piston 80, which I call a floating piston, is freely slidable in piston chamber 52. Preferably piston 80 is an annulus with a central cylindrical bore 81 slidable on the cylindrical face 82 of valve rod 71 there being suitable O ring, or other seals, 83 on the exterior and interior thereof to prevent leakage of fluid thereby while permitting the piston to slide in the chamber and on the rod. Each opposite face 84 and 85 of the piston 80 is provided with grooves 86 or 87 extending from the bore 81 outwardly, the grooves preferably being radial. Similarly the axially extending tapered grooves 75 and 76 of the valve 71 are of predetermined length such that when the piston and rod are at the far end of their paths, as shown in FIGURE 5, the shallow end of the rod grooves and the adjacent piston grooves are always connected by a counter bore 88 or 89 to form a fluid passage of predetermined reduced cross section. Thus influent fluid in port 45 can always pass along a rod groove, out a radial groove to exert pressure on the adjacent face of the piston.

Each adjusting screw 62, or 63, includes an annular shoulder 90, a locking nut 91 and a terminal tip 92 which serves as an adjustable stop for controlling the length of travel of the valve rod 71 at each opposite end of its path. The screws 62 and 63 are shown in minimum stroke condition in FIGURE 5 with the tapered grooves 76 just reaching to radial grooves 86. This position provides maximum cushioning effect for a minimum time period. Tightening of the screws 62 and 63 toward each other will reduce the length of the stroke of the rod 71, increase the minimum size of the orifices and reduce the cushioning effect, and increase the time of operation correspondingly.

Because of the provision of the fixed orifice of minimum size, explained above and designated 93 in FIGURE 5, the cushion piston 80 and valve rod 71 never totally close the orifices entirely in the manner of a check valve but simply change orifice size between a predetermined maximum area and a predetermined minimum area. Thus the impact and shock of total closure is eliminated.

As shown diagrammatically in FIGURE 1, the pump 21 is forcing the hydraulic fluid in the direction of the full headed arrows to force piston 24 to the left and hold cushion piston 80 and valve 71 at the left end of the cushion cylinder so that full pressure is being exerted on the work piston. The half headed arrows represents flow of the fluid back toward the pump and reservoir. The fluid pressure has moved the valve 71 to the left by pressure exerted against the tapered bottom of the grooves 75 and moved the cushion piston to the left by pressure on the face 85. The flow passage at 93 is open, but back pressure therethrough against the face 84 of piston 80 is minimal.

In FIGURE 2 the system 20 is illustrated diagrammatically with the control mechanism 38 suddenly shifted from the position of FIGURE 1 in which piston 24 is advancing, to a position in which the flow is stopped, or reversed, the piston 24 being intermediate of its cylinder 23. As shown by the full headed arrows, the pump 21 is now exerting pressure on the opposite face of work piston 24 to thrust it to the right and in conventional systems shock would be great. However, in the system of this invention, the pressure exerted by the pump 21 in conduit 32 has been partly diverted into the conduit

means 43, into influent port 45 and against valve 71 to push the valve entirely to the right and to push the cushion piston toward the right. The cushion piston 80 now receives all of the shock pressure, this pressure forces piston 80 to the right and expels fluid through the orifice now established by valve 71 which is bearing against the face 92 of adjusting screw 63. The effluent hydraulic fluid is thus expelled through orifice 75, port 46 and conduit 44 to enter the main system to flow through conduit 44 or conduit 37 as the need of the system demands.

As shown in FIGURE 3 the valve 71 is maintained by pump pressure fully to the right, cushion piston 80 has moved further to the right, and all shock forces have been absorbed to permit the decelerated work piston to travel to the right.

In FIGURE 4 the work piston is shown continuing to travel to the right, or retract, while the remote hydraulic cushion assembly is in stand-by position waiting another change of flow direction.

I claim:

1. In a hydraulic system of the type comprising a hydraulic pump for generating force; a double acting work cylinder having a piston for performing mechanical work; hydraulic conduits connecting each opposite end of said cylinder with said pump and control mechanism, associated with said pump, for selectively stopping, or reversing, the flow of incompressible hydraulic fluid filling said system, the combination of:

a remote, hydraulic cushion assembly for reducing shock to said system caused by stoppage, or direction change, of a loaded piston at any location along said cylinder, said assembly comprising:

a double acting, cushion cylinder having a centrally disposed piston chamber therewithin, and having a pair of valve bores, each bore opening into said chamber at an opposite end of said cylinder;

conduit means connecting each said bore with one of the ends of said work cylinder;

a double acting valve axially slidable in said cushion cylinder, each opposite end thereof having means forming orifices in cooperation with one of said bores for throttling flow from said piston chamber to the adjacent conduit means, and

a piston axially slidable in said piston chamber, said piston being cooperable with said valve to create progressively diminishing back pressure on the piston of said work cylinder when flow in said system is stopped or reversed in direction.

2. A hydraulic system as specified in claim 1 wherein said double ended valve is a cylindrical rod with tapered, grooved ends and said bores are each cylindrical, said grooves and bores forming said orifices and said orifices becoming progressively smaller as each end of said rod moves further into its bore.

3. A hydraulic system as specified in claim 1 wherein said double acting valve is a cylindrical rod and said piston is an annulus slidable on said rod.

4. A hydraulic system as specified in claim 1 wherein said piston is an annulus axially slidable on said valve, each said valve end is axially grooved and each opposite face of said piston is radially grooved and counter bored to register therewith for providing a permanent fluid passage of predetermined cross section from each opposite end of said piston chamber to the adjacent conduit means.

5. A hydraulic system as specified in claim 1 plus means at each opposite end of said cushion cylinder for adjusting the length of the stroke of said valve to thereby adjust the size of said orifices.

6. In a positive displacement hydraulic system having a double acting, work cylinder, a source of hydraulic fluid under pressure and control mechanism for reversing flow of said fluid the combination of:

a double acting cushion cylinder mounted in said system in parallelism with said work cylinder, said cushion cylinder having a piston chamber with a

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fluid port at each opposite end thereof connected to the corresponding end of said work cylinder;
 a piston floatingly mounted within said chamber for free axial movement therealong from proximate one said port to proximate the other said port, and
 throttle valve means including orifices associated with each said port, said means being operable, to progressively diminish flow through the port approached by said piston and to correspondingly increase flow through the other said port.

7. A hydraulic system as specified in claim 6 wherein said double acting cushion cylinder includes adjustment means at each opposite end thereof, for varying the effective cross sectional area of the orifices of said throttle valve means.

8. A hydraulic system as specified in claim 6 wherein said throttle valve means is a rod having axially extending, tapered grooves in each opposite end, each end closely fitting, and being slidable, in a bore at each opposite end of said chamber to define a series of said orifices therearound leading to one of said ports whereby influent fluid moves the adjacent end of said rod out of its bore to increase the size of the orifices at that end while the other end of said rod is moved into its bore to decrease the size of the orifices at said other end.

9. A reversible, hydraulic cushion cylinder for use in a closed, hydraulic, reversible pump and motor system

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said cushion cylinder having a centrally disposed, axially extending piston chamber therewithin and a fluid port at each opposite end thereof;

a piston mounted within said chamber for axial movement therealong by pressure of influent fluid while exerting corresponding pressure on effluent fluid, and

throttle valve means, independently movable axially relative to said piston, associated with each said port, and operable by pressure of influent liquid to progressively diminish flow through each effluent port while correspondingly increasing flow through each influent port.

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