May 30, 1967 R. A. MADLAND 3,322,039

HYDRAULIC CUSHION

Filed Jan. 7, 1966

FIG. 1

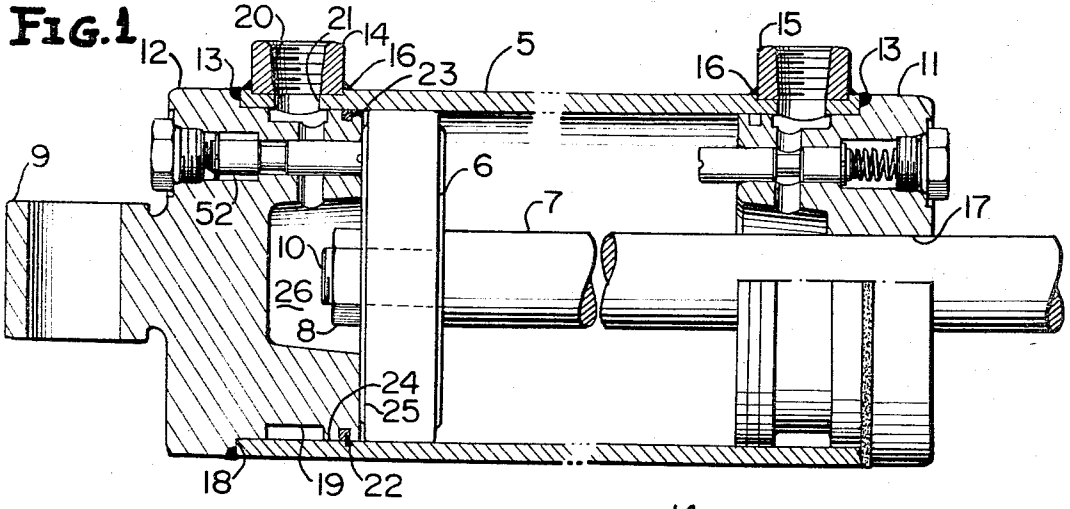


FIG. 2

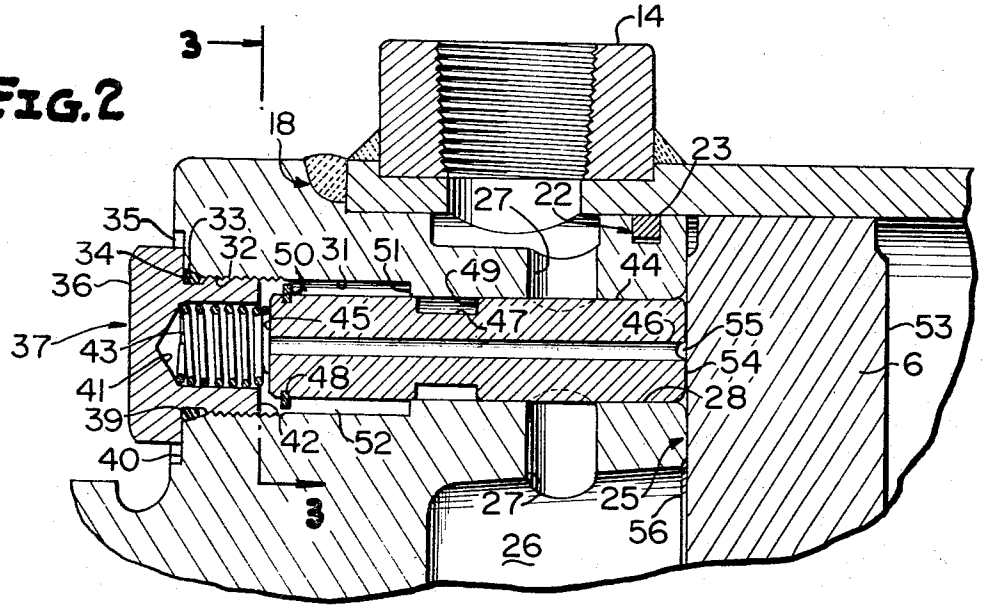
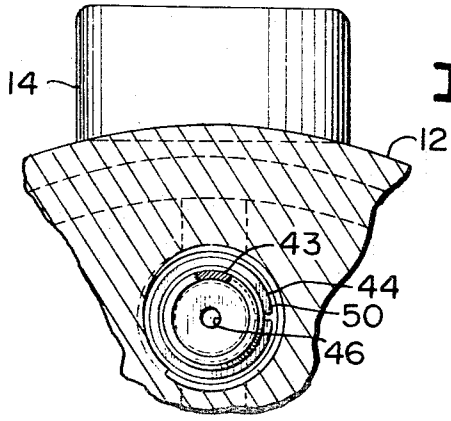


FIG. 3



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HYDRAULIC CUSHION

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This invention relates in general to new and useful improvements in hydraulic cylinder and piston art, and more particularly seeks to provide a novel means for cushioning the travel of a piston during the terminal portion of its stroke in the cylinder in which it operates.

An object of this invention is to provide in a cylinder and piston structure, novel means for cushioning a terminal portion of a piston stroke and including a valve plunger having a groove therein movable out of registry with a fluid passage to first throttle and then trap fluid whereby entrapped fluid serves to cushion terminal movement of the piston, fluid pressure of trapped fluid on one end of said plunger being at substantially the same pressure as that opposing the opposite end of the plunger by the fluid disposed in advance of the piston being cushioned and which is engageable with said opposite plunger end.

Another object of this invention is to provide a novel piston travel cushioning means of the character stated including a plunger valve which is shiftable by piston engagement and which is pressure balanced at its opposite ends in the manner stated so that a compression spring engaged with an outer end portion thereof is effective to return the plunger from its active fluid throttling and trapping positions to a projected inoperative position in which its groove is placed to permit free fluid passage.

Yet another object of this invention is to provide a double acting pressure cylinder having at each end thereof one of the novel plunger mechanisms, thereby to provide a fluid cushioning at each associated end of the piston, during the terminal portion of the stroke of the piston.

With the above and other objects in view that will hereinafter appear, the nature of the invention will be more clearly understood by reference to the following detailed description, the appended claims and the several views illustrated in the accompanying drawings.

In the drawings:

FIGURE 1 is a longitudinal sectional view illustrating the double acting piston and cylinder of this invention, parts being shown in elevation.

FIGURE 2 is an enlarged fragmentary sectional view illustrating the novel cushioning mechanism of this invention in its operative position.

FIGURE 3 is a fragmentary vertical cross-sectional view taken on the line 3—3 of FIGURE 2.

Referring now to the drawings in detail, reference is first made to FIGURE 1 wherein there is illustrated a pressure cylinder 5 having a piston 6 mounted for reciprocation therein, the piston 6 having a piston rod 7 secured centrally thereof by a nut 8 fastened onto a fitted end 10 of the rod 7. The other end of the piston rod 7 extends longitudinally of the cylinder 5 and through an end wall or closure head 11. Another end wall or closure head 12 is mounted on the other end of the cylinder and has a projection or aperture mounting ear 9 thereon for pivotal engagement with an anchoring means or connection member (not shown). The end wall members 11, 12 are secured to the cylinder 5 by groove welds 13, or by any other appropriate means. Inlet and exhaust ports 14 and 15 are provided, and in this illustration are shown secured to the outer surface of the cylinder 5, as by fillet welds 16, or any other approved means. With the exception of the mounting ear 9 attached to the end wall 12, and a bore 17 in the end wall 11 to receive the piston rod 7, the end walls 11 and 12 are of substantially identical construction. Therefore, only a single end wall and its components will be described in detail.

The end wall 12 has an outer peripheral shoulder portion 18 engaging an end of the cylinder 5 and a recess to receive the weld 13. Spaced inwardly of the shoulder 18 is a peripheral groove 19 extending entirely around the outer surface of the end wall 12 but at a point spaced longitudinally inwardly from the end of the cylinder 5. The groove 19 communicates with the inner surface 20 of the port 14 through an aperture 21 extending through the wall of the cylinder 5. Another groove 22 is positioned longitudinally inwardly of the groove 19 of the wall 12 and is adapted to receive a sealing ring 23 effective to prevent leakage of fluid outwardly about the exterior of the reduced diameter portion 24 of the end wall telescoped into the cylinder. The inwardly directed surface 25 of the end wall 12 is presented to serve as an abutment for the opposing face 56 of the piston 6.

A chamber 26 is formed as a central depression in the end wall 12 and communicates with the previously mentioned groove 19 by means of a radial bore or passageway 27 extending outwardly across or intersecting a longitudinal bore 28, thereby paralleling the axis of the end wall 12 and cylinder 5. The bore 27 opens outwardly into the groove 19 and the port 14. The bore 28 extending outwardly of the cross bore or duct 27 opens into a counterbore 31, said counterbore 31 being internally threaded at 32 and provided at its outer extremity with a chamfer 33. The chamfer is adapted to receive an O-ring seal 34 and opens into a further counterbore 35 adapted to receive a head 36 on a bore closure plug member 37. The plug member 37 is threaded into the tapped hole 32, compressing the O-ring seal 34 between the chamfer 33 and the grooved wall portion 39 of the plug 37 when the head 36 of the plug 37 is secured against the outwardly presented surface 40 of the counterbore 35. The plug 37 has a central bore 41 in which to receive a compression spring 43.

A plunger 44 is slidably mounted in the bore 28 and is substantially aligned with the bore 41 in the plug 37. The spring 43 is disposed to abut against the end surface 45 of the plunger 44 and bias the plunger 44 in a direction toward the interior of the cylinder 5. The plunger 44 has an axial bore 46 and an annular groove 47 disposed about this periphery. The groove 47 is defined in part by a cut-off edge 49 and is adapted to be aligned with the bore 27 when the plunger is in the inoperative or spring projected position shown at the right in FIGURE 1. Another groove 48 is provided in the periphery of the plunger 44 adjacent the outer end 45 thereof, and is adapted to receive a snap ring 50. The snap ring 50 is positioned to be engageable with the abutment wall 51 to limit the inward travel of the plunger 44 in response to the force exerted by the spring 43 in which extreme inward position the plunger groove 47 is placed to align with the bore 27 as shown at the right in FIGURE 1. The space defined exteriorly of the outer end of the plunger 44 by the counterbore 31 in the end wall 12, the abutment surface 51, the bore 41 and the inner surface 42 of the plug 37 defines a chamber 52.

When the plunger 44 is in the last-mentioned extreme inward or inoperative position, fluid from the chamber 26 is in communication with the bore 27, the groove 47 of the plunger 44, the aperture 21 of the cylinder 5, and the port 14. Fluid from the chamber 52 is in communication through the center bore 46 of the plunger 44, with a port or groove 55 extending radially outwardly across the inner end surface 54 of the plunger 44, and with the interior of the chamber 26 and the fluid therein.

As a high pressure fluid acting against the surface **53** of the piston **6** drives the piston toward the terminal portion of its stroke, the piston contacts the inner end surface **54** of the plunger **44** and moves the plunger longitudinally against the force exerted by the spring **43**. The groove **47** in the plunger **44** then begins to move out of registry with the bore **27**, thereby causing a throttling of the fluid attempting to pass out through the bore **27**. In response to further longitudinal movement of the piston **6**, the edge **49** of the plunger groove **47** passes the bore **27**, thereby causing the outer portion of the bore **27**, the cylinder port aperture **21** and the bore **14** to be out of communication with the fluid thus trapped in the chamber **52**, the bore **46** and the chamber **26**, and further longitudinal movement of the piston **6** toward the end wall **12** is opposed and cushioned by said trapped fluid. Because all of the fluid in this trapped or closed system is at the same pressure for any given position of the piston **6** after the groove **47** of the plunger **44** moves out of communication with the bore **27**, the fluid pressure on opposite end surfaces **45** and **54** of the plunger is equal. This closed fluid pressure system acts as a cushion on the surface **56** of the piston **6**, thereby retarding the velocity of the piston **6** in the terminal portion of its stroke. It will be apparent by reference to FIGURE 2 that the plunger bore **46** and cross groove **55** will permit restricted escape of fluids from the entrapment chamber **52** as the piston surface **56** comes against the plunger **44** and forces it from its projected position shown at the right in FIGURE 1 toward the full cushion effected position shown in FIGURE 2.

Also, because the pressure on opposite end surfaces **45** and **54** of the plunger **44** is equal, the force of the spring **43** against the surface **45** of the plunger **44** is the only substantial force acting upon the plunger **44** to return the plunger **44** to its inoperative or inwardly projected position, and as the high pressure is withdrawn from the fluid acting upon the face **53** of the piston **6**, the spring **43** is effective to move the plunger **44** longitudinally so that the groove **47** of the plunger **44** is again brought into communication with the bore **27** of the end wall **12** as shown at the right in FIGURE 1. Pressurized fluid may then be applied through the port **14**, through the bore **27**, and against the face **56** of the piston **6**, to drive the piston toward the end wall **11** in the same manner as hereindescribed for the movement of the piston toward the end wall **12**, in the usual manner of a double acting cylinder.

Although only a preferred embodiment of the invention has been illustrated and described herein, it is to be understood that modifications may be made in the disclosed structures without departing from the spirit and scope of this invention as defined in the appended claims.

What is claimed is:

1. A pressure cylinder having end closures, pressure fluid inlet and outlet porting at the ends thereof and a piston reciprocable therein between said closures, and a terminal stroke cushioning means in at least one of said closures for cushioning terminal stroke movement of the piston theretoward, said one closure having a pressure chamber therein in which to receive pressure fluid in advance of the piston when moving theretoward and said cushioning means including a longitudinal bore having one end thereof opposed to the piston, a valve plunger means including a valve plunger slidable in said bore and a spring for constantly tending to project the inner end of the plunger a predetermined distance from the bore in position for engagement by the piston, a duct traversing said bore and communicating between said chamber and the particular cylinder end porting, means for bleeding pressure fluid from the bore from behind the plunger back into the cylinder, and a cross clearance in the plunger placed to afford communication of pressure fluid from said chamber to said particular cylinder porting and presenting shoulder means for throttling said communication as the piston engages and moves the plunger outward from its inwardly projected position.

2. The combination of claim **1** wherein the valve plunger has a like area at each end presented respectively to fluid pressure in the bore in said one closure behind the plunger and in the cylinder between said one closure and the piston.

3. The combination of claim **1** wherein the pressure bleeding means comprises chamber space behind the plunger and a bleed passage extending through the valve plunger and each end thereof.

4. The combination of claim **1** wherein the cross clearance in the valve plunger comprises an annular groove formed in the plunger exterior.

5. The combination of claim **1** wherein the pressure bleeding means comprises chamber space behind the plunger and a bleed passage extending through the valve plunger between the ends thereof, and a cross groove traversing the piston opposing end of the plunger and disposed to provide cross clearance when the piston is against the plunger.

6. The combination of claim **1** wherein the pressure bleeding means comprises chamber space behind the plunger and a bleed passage extending through the valve plunger between the ends thereof, and a cross groove traversing the piston opposing end of the plunger and disposed to provide cross clearance when the piston is against the plunger, said chamber space being defined in part by a removable plug mounted in said one closure and providing a back up for the spring and an access opening through which the plunger may be serviced.

7. The combination of claim **1** wherein the cross clearance in the valve plunger comprises an annular groove formed in the plunger exterior, and there is also included means limiting projection of the plunger from the bore in which it is mounted at the point at which said annular groove is in register with the bore traversing duct.

8. The combination of claim **1** wherein said spring alone provides the means for returning said plunger to its inward position wherein said duct is in communication with said bore.

9. The combination of claim **1** wherein said cylinder is of the double acting type having substantially identical cushioning means at each of its ends, each of said cushioning means being associated with an adjacent face of said piston.

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