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CYLINDER WITH PISTON CUSHIONING FEATURE
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This invention relates to fluid pressure operable power cylinder devices and, more particularly, to such a device having improved means for cushioning the piston on the last part of its stroke in either one or both directions of travel.

It is a well-known fact that in order to provide efficiency of operation, less wear due to excessive vibration and more silent operation, it is highly desirable to cushion or buffer the piston during the final portion of its stroke, either in one direction or both, to prevent excessive knocking against the pressure heads or kickback of the piston. Depending upon the amount of force applied to the pressure face of the piston for effecting movement thereof, the length of piston travel or stroke and the rate at which it moves, along with other pertinent factors, it is also desirable to provide some means in the cylinder device for varying the cushioning effect accordingly, that is, the distance or portion of the piston stroke during which the cushioning is effective.

Accordingly, the object of the invention is to provide a fluid pressure operable power cylinder device having improved means for cushioning or buffering the final portion of the stroke of the piston in one or both directions of travel and means for varying the distance of said final portion of said stroke over which the cushioning action is effective. Briefly, the invention comprises a cushioning valve closure member supported for coaxial sliding movement relative to a piston rod, a spring attached at one end to the cushioning valve closure member and at its other end to the piston and piston rod assembly, the spring constituting the sole motive connection between the cushioning valve closure member and the piston and piston rod assembly such that cushioning of the piston stroke is effected over a terminal portion thereof by compression of the spring and the fluid medium trapped between the cushioning valve closure member and the piston assembly upon seating of said valve closure member. By providing springs of varying lengths, the length of the cushioned portion of the stroke may be varied accordingly. If it is desired to cushion the piston at both ends of the stroke, two cushioning valve arrangements may be mounted in the cylinder device on opposite sides of the piston assembly.

In the accompanying drawing, FIG. 1 is a sectional view of a cylinder and piston assembly having means for cushioning the piston at one end only of the stroke, and FIG. 2 is a sectional view of a cylinder and piston assembly having means for cushioning the piston at both ends of the stroke.

Description and Operation—FIG. 1

Referring now to FIG. 1, it will be seen that the cylinder device is constructed largely from tubular components, thereby reducing the number of parts and machining operations required to make it, as well as its weight. The assembly comprises a tubular cylinder 1 within which is mounted a reciprocable tubular piston rod 2 shown at the working limit of its inward stroke. The exterior end 3 of the piston rod 2 is adapted to be connected to an apparatus, such as a door operator, or linkage (neither of which is shown), and passes out of the end of the cylinder 1 through an end cover or pressure head 4 provided with drilled holes or passageways 5 extending from

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the interior of the cylinder to a pipe connection port 6. The other end 7 of the piston rod 2 carries a cushioning valve assembly including a spring 8, one end of which is attached to a cushioning valve closure member, shown generally at 9, comprising a flat faced valve element 10 surrounding and loosely mounted upon the piston rod 2 so as to be axially slidable thereon, and provided with a packing cup 11 held in position against the valve element 10 by a locking nut 12 which also retains one end 13 of the spring 8.

The spring 8 encircles the piston rod 2 and its other end 14 is attached to a piston follower 15. The piston follower 15 is carried on a reduced diameter terminal extension 16 of the piston rod 2 and abuts a piston 17. Oppositely directed packing cups 18 and 19 are provided on either side of the piston 17, which has a clearance fit within the cylinder, and the assembly comprising, in order, the piston follower 15, packing cup 18, piston 17 and packing cup 19 is held in position on the end of the piston rod 2 by means of a locking nut 20 and collar 21.

The apparatus illustrated in FIG. 1, when used as a door operating engine, operates in the following manner:

Compressed fluid, such as air, is passed into the cylinder 1 through a pipe connecting inlet port 22 into a chamber formed between piston 17 and an end cover or pressure head 23 at the end of said cylinder opposite cover 4 and acts upon the packing cup 19, the air being prevented from leaking past the piston and piston rod 2 by means of a sealing ring 24. As the piston 17 moves out, the valve assembly 9 is carried along the cylinder by means of the spring 8 until it occupies a seated position on an annular valve seat 25 formed on the inner face of end cover 4 surrounding piston rod 2. Until this occurs the air in a chamber formed in the cylinder 1 between the valve assembly 9 and end cover 4 exhausts rapidly and freely through the holes 5. As soon as the valve element 10 closes on its seat 25, the remaining air trapped in the cylinder between the packing cups 11 and 18 may exhaust only through the annular space afforded by the sliding fit of the valve assembly 9 on the piston rod 2 and thence through the clearance between the piston rod and the wall of the bore in end cover 4 through which the piston rod passes and a branch passage 26, opening into the port 6. The branch passage 26 may be provided in known manner, if desired, with an adjustable needle choke valve 27 for controlling the opening of an orifice 28 in said branch passage. It should be understood that the needle choke valve 27 is not essential in the cushioning operation but merely provides an additional means for finer adjustment of exhaust of fluid after seating of valve 10 on seat 25.

Since this exhaustion amounts to a mere leakage, the air trapped between the packing cups becomes compressed as the piston continues to move outwardly in the cylinder 1, this compression providing a cushioning or buffering over the terminal portion of the piston stroke thus slowing the piston 17, piston rod 2 and the door, connected thereto, for the last portion of travel of the piston assembly. The length of this portion is determined by the length of the spring 8, the compression of this spring, as the piston finally comes to a standstill, augmenting the cushioning effect of the air compressed between the packing cup 11 and 18. Leakage of this air directly to atmosphere is prevented by suitable sealing means in the end cover 4 around piston rod 2, such as those shown at 29 and 30.

To return the piston to its inner position (door closed), as shown in FIG. 1, compressed air is passed into the cylinder through the port 6 in the end cover 4, and thence through the holes 5. This air is forced past the packing cup 11 and acts upon the packing cup 18 adjacent

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piston 17 and piston follower 15, thereby withdrawing the piston rod, the valve assembly 9 being carried back along the cylinder 1 by the spring 8. It will thus be seen that the cylinder device is basically a long stroke, double-acting piston and cylinder which can be conveniently connected directly between the door or apparatus to be operated and its supporting structure.

The cushioning valve assembly 9 is connected to the piston 17 by the spring 8 only and the construction of this valve assembly is such that no separate check valve is required, the packing cup 11 on the cushioning valve assembly 9 acting both as a seal on the operational cylinder bore, trapping the cushioning air, and also as a quick relief valve on the application of air through the end cover 4, permitting the full pressure of the air supply to be applied to the packing cup 18 adjacent the piston 17.

The packing cup 11 also acts as a guide for the cushioning valve assembly 9, being loosely guided on the piston rod 2, so that the compressed cushioning air is exhausted through the center opening or bore of the valve assembly 9 via the inside of the valve seat 25 on the end cover 4 and choked orifice to the main exhaust which is connected to the annulus around the outside of the valve seat through which the cylinder 1 is exhausted before the cushioning valve 10 is seated, thereby facilitating the simple and inexpensive construction of the cylinder 1, and reducing the amount of precision machining necessary.

Description and Operation—FIG. 2

It will be readily understood that while the apparatus according to FIG. 1 provides cushioning at only one end of the piston stroke, it may be easily modified to provide cushioning at both ends of the piston stroke. FIG. 2, which illustrates such a modification, shows an arrangement of a cushioning valve assembly 31 and an associated piston 32 and valve seat 33 which parts are similar to those described with reference to FIG. 1 and operate in a similar manner. Port 6 in the modified version of the invention shown in FIG. 2, however, opens into an annular recess surrounding the valve seat 33. A small port 34, or a plurality thereof, if so desired, may be formed transversely in the valve seat 33 to provide restricted escape of fluid trapped between the cushioning valve assembly 31 and piston 32 through said small port, the recess surrounding the valve seat 33 and out port 6 when said cushioning valve assembly is seated against valve seat 33.

To cushion the end of the inward stroke of the piston rod 2, however, there is provided, as shown in FIG. 2, a further cushioning valve assembly 35 connected by a spring 36 to a collar 37 adjacent the packing cup 19 and piston 32.

The arrangement shown in FIG. 2 operates to cushion the inward stroke of the piston rod in substantially the same way as that already described with reference to FIG. 1 for the outward stroke, the spring 36 having one end 38 connected to a retaining groove in a guiding member 39 which is threaded to receive a cushioning valve 40, the valve 40 being screwed thereon to retain a packing cup 41 in position and also to effect closure on a seat 42 when the piston rod moves inwardly.

Having now described the invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a power cylinder device, the combination comprising a cylinder, respective pressure heads for closing the opposite ends of said cylinder, a piston cooperating with said cylinder and said pressure heads for forming two respective chambers therein on opposite sides of the piston, said piston being movable responsively to pressure of fluid admitted into one of said chambers adjacent the respective pressure head in a direction toward the other pressure head, said other pressure head including a passageway providing for exhaust flow of fluid from the other chamber adjacent thereto at an unrestricted rate during a predetermined distance of initial piston move-

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ment, a piston-cushioning member coaxially movable in said cylinder in sealing relation therewith between said piston and said other head, and a spring interposed between said piston-cushioning member and the piston for transmitting motive force from the piston to the piston-cushioning member for moving the latter to an abutting position against said other pressure head upon completion of said predetermined distance of initial piston movement, said piston-cushioning member including passage means effective when said piston-cushioning member is in said abutting position for limiting exhaust flow of fluid trapped in said other chamber between said piston and said piston-cushioning member to a restricted rate.

2. In a power cylinder device, the combination of a cylinder, respective pressure heads for closing the opposite ends of said cylinder, a piston cooperating with said cylinder and said pressure heads for forming two respective chambers therein on opposite sides of the piston, said piston being movable by admission of fluid under pressure into one of said chambers adjacent one of said pressure heads in a direction toward the other pressure head, said other pressure head having formed therein a first passageway through which fluid in the other chamber is displaced at an unrestricted rate during a portion of initial movement of said piston, and having an annular valve seat formed thereon, and piston-cushioning valve means yieldingly connected to said piston and axially movable thereby in said cylinder in sealing relation therewith to a seated position, upon completion of said specified portion of movement of said piston, on said valve seat formed on said other pressure head for closing communication between said other chamber and said first passageway, said piston-cushioning valve means including passage means effective when said piston cushioning valve means is in its said seated position for limiting escape of fluid trapped between said piston-cushioning valve means and said piston to a restricted rate during the remainder of the piston stroke.

3. In a power cylinder device, the combination of a cylinder, respective pressure heads for closing the opposite ends of said cylinder, a piston in said cylinder movable by fluid under pressure supplied to a first chamber between said piston and one of said heads in the direction of the other head, said other head having formed therein a first passageway and a second passageway via which fluid escapes from a second chamber between said piston and said other head during movement of said piston toward said other head, a piston rod for said piston movable therewith and extending coaxially from one side thereof through said other head in slidable sealing relation thereto, piston-cushioning valve means coaxially and slidably operable within said cylinder in sealing relation therewith and loosely encircling said piston rod so as to provide a restricted clearance between said piston rod and said piston-cushioning valve means and permit relative axial movement therebetween, a spring having one end attached to said piston-cushioning means and the other end attached to said piston thereby constituting a yieldable motive connection between said piston-cushioning valve means and said piston, a valve seat formed on said other head, a valve element carried by and movable with said piston-cushioning means to occupy, upon completion of a certain initial portion of said piston movement and also during the balance of the piston stroke, a seated position of said valve element communication through said first passageway is closed against further venting of fluid trapped between said piston-cushioning valve means and said piston, said further venting being restricted via said annular clearance and said second passageway.

4. In a power cylinder device, the combination comprising a cylinder, respective pressure heads for closing the opposite ends of said cylinder, a piston movable in said cylinder by admission of fluid under pressure into

one of two respective chambers formed by said cylinder, said piston and said pressure heads on opposite sides of said piston, in a direction toward the opposite pressure head, said opposite pressure head having formed therein a first passageway and a second passageway via which fluid escapes from the other chamber during movement of said piston toward said opposite pressure head, a piston rod movable with said piston and extending coaxially through said cylinder from one side of said piston through said opposite pressure head in slidable sealing relation thereto, a piston-cushioning valve member coaxially operable in said cylinder in sealing relation therewith and loosely encircling said piston rod so as to provide a restricted annular clearance between said piston-cushioning valve member and said piston rod and permit relative axial movement therebetween, a spring having one end attached to said piston and the other end attached to said piston-cushioning valve member for providing a yieldable motive connection therebetween, an annular valve element carried by said piston-cushioning valve member and encircling said annular clearance, and an annular seat formed on said opposite pressure head and engaged by said valve element in a seated position thereon, upon completion of a certain initial portion of the piston stroke and also for the balance of the piston stroke, in which seated position of said valve element said first passageway is isolated outside the limits of said valve seat against further venting therethrough of fluid trapped between said piston-cushioning valve member and said piston, said further venting being limited to said restricted annular clearance and said second passageway.

5. In a power cylinder device, the combination of a cylinder, respective pressure heads for closing the opposite ends of said cylinder, a piston cooperating with said cylinder and said heads to form respective chambers therein on opposite sides of the piston, said piston being movable responsively to pressure of fluid admitted into one or the other of said chambers in a corresponding direction toward the oppositely situated pressure head, each of said pressure heads being provided with an unrestricted passageway and a restricted passageway via which fluid escapes from the respective adjacent chamber during movement of said piston toward the respective pressure head, a piston rod associated with said piston for movement therewith and extending coaxially from one side of said piston through said one chamber and the respective adjacent pressure head in slidable sealing relation with the latter, a first piston-cushioning valve member coaxially operable in said cylinder in said one chamber in sealing relation with the cylinder and loosely encircling said piston

ton rod so as to provide an annular restricted clearance between said first piston-cushioning valve member and said piston rod and permit relative axial movement therebetween, a first spring having one end attached to said first piston-cushioning valve member and the other end attached to said piston thereby providing a yieldable motive connection therebetween, a first valve seat formed on the pressure head adjacent said first piston-cushioning valve member, a first valve element carried by and movable with said first piston-cushioning valve member to occupy, upon completion of a predetermined initial portion of said movement of said piston in one direction toward the respective pressure head and also during the balance of the piston stroke, a seated position on said first valve seat, in which seated position of said first valve element communication through said unrestricted passageway in the respective pressure head is closed against further venting of fluid trapped between said piston and said first piston-cushioning valve member, said further venting being restricted via said annular clearance and the restricted passageway in the respective pressure head, a second piston-cushioning valve member coaxially operable in said other chamber in sealing relation to the cylinder, a second spring having one end attached to said second piston-cushioning valve member and the other end attached to said piston thereby providing a yieldable motive connection therebetween, a second valve seat formed on the pressure head adjacent said second piston-cushioning valve member, and a second valve element carried by and movable with said second piston-cushioning valve member to occupy, upon completion of a predetermined initial portion of said movement of said piston in a direction opposite said one direction toward the respective pressure head and also during the balance of the piston stroke, a seated position on said second valve seat, in which seated position of said second valve element communication through said unrestricted passageway in the respective pressure head is closed against further venting of fluid trapped in said other chamber between said piston and said second cushioning member, said last-mentioned further venting being restricted via the restricted passageway in the respective pressure head.

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