

April 26, 1966

W. ASLAN  
FLUID CYLINDER

3,247,767

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2 Sheets-Sheet 1

FIG. 1

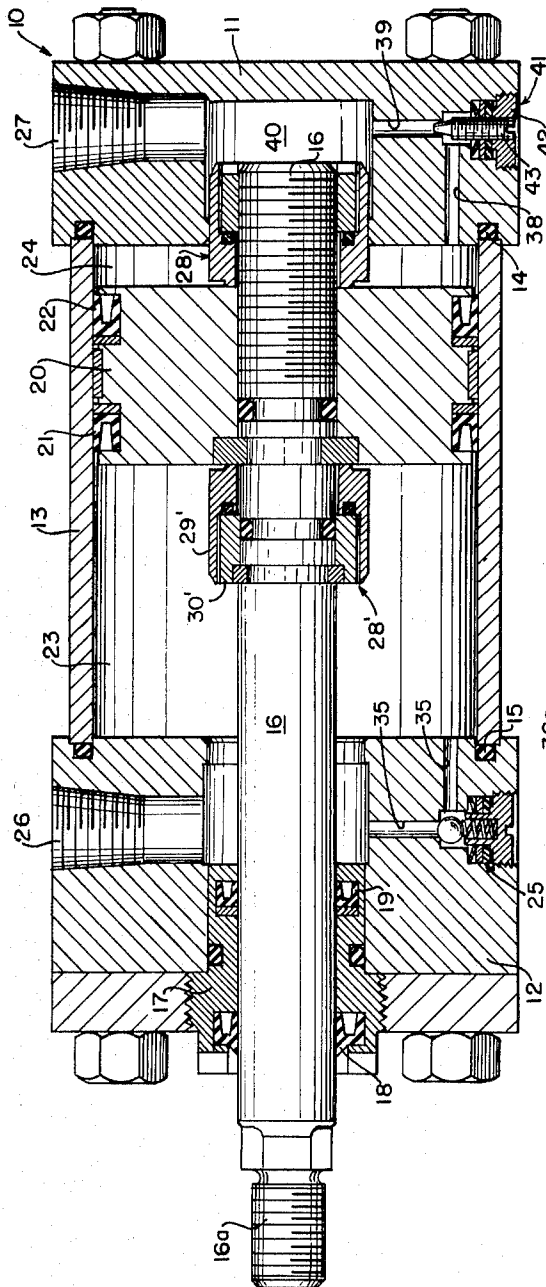


FIG. 3

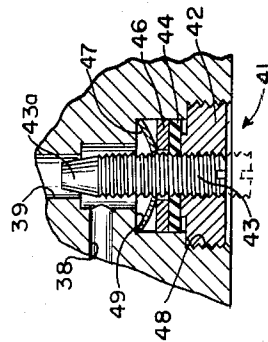
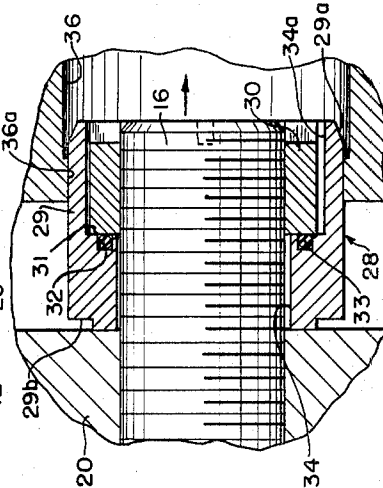


FIG. 2



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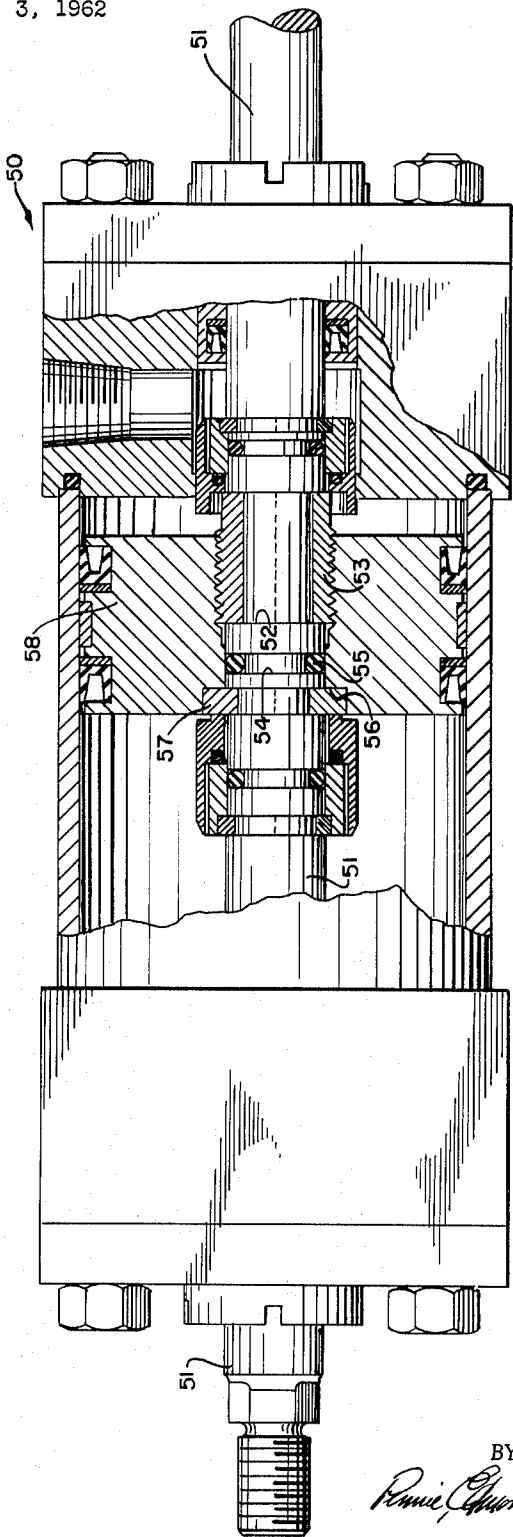
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FIG. 4



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3,247,767

## FLUID CYLINDER

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This invention relates generally to improvements in fluid cylinders of the pneumatic or hydraulic type and specifically to improved arrangements for mounting pistons in double rod-ended cylinders, for cushioning the piston at the end of its travel and for sealing an adjustable member which meters a bypass passage for the cushioning fluid.

Cushioning is provided for the end travel of pistons in pneumatic and hydraulic cylinders to prevent destructive impacting of parts, to reduce noise level from impacting and to reduce vibration. The conventional practice is to seal off the major portion of exhaust flow immediately prior to the termination or end of stroke position of the piston, thus permitting pressure to build up against the exhaust side of the piston to provide a decelerating effect. For example, just prior to the completion of the stroke a cushion element or plug may be permitted to enter a bore within the end cap of the cylinder, thereby cutting off the exhaust path and trapping a quantity of air or hydraulic fluid between the piston and the cap. The trapped air or oil is metered to exhaust thereafter at a slower rate and it is this metering action which provides the cushioning effect at the end of the stroke. Several problems are encountered in manufacturing a cushion of the aforementioned type since the efficiency of the cushioning effect depends upon the sealing which is obtained between the cushion and the bore within the end cap. This sealing efficiency is related directly in prior designs to the concentricity of the piston rod and piston with respect to the cushion bore since it is this feature that must be controlled in arriving at acceptable tolerances between the outside diameter of the cushion and the inside diameter of the bore which receives the cushion in sealing engagement.

Attempts have been made to solve the problems of eccentricity between the cushion and its bore, it being understood that this eccentricity will normally result from the cumulative effect of manufacturing tolerances or from the wearing of parts, etc. One proffered solution is to mount O-ring, U-cup or other forms of lip-seals within the cap bore for engagement with the cushion plug or element. As the cushion engages the sealing elements flow or expand to fit, creating a relatively tight seal. Such seals however, generally limit the allowable pressure rating to below 250 p.s.i. and have a history of failure due to tearing, extruding, or blowing out of their housing grooves and into the cylinder chamber.

A further solution, a so-called "floating cushion" for accommodating eccentricity between the cushion plug and its bore has been proposed in order to avoid deficiencies inherent in designs wherein the cushion element is rigidly mounted relative to the longitudinal axis of the cylinder. According to this arrangement, if the cushion enters its bore eccentrically, it is "bumped" radially an amount sufficient to match the center of the bore, and the resilient packing under the cushion compensates for the eccentricity to seal the clearance. This method permits the manufacturer to reduce the fit of the cushion to the housing bore, thereby improving cushion efficiency. There are, however, two major deficiencies in this type of floating action. First, the cushion is bumped off center respective of its mounting axis on every stroke (due to the resilient return action of the packing) which causes eventual wear

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or galling of the cushion and its bore. Secondly, the clearance between the cushion and the piston rod reduces substantially the life of the cushion O-ring and provides an extrusion path and failure of the O-ring at higher pressures.

I have devised a floating cushion for air or hydraulic cylinders which overcomes the above-mentioned deficiencies. In accordance with a primary aspect of the present invention, a cushion is mounted with a degree of radial freedom relative to the axis of the piston shaft and is urged upon the first stroke of the piston into a position of concentricity with respect to the cushion bore. The design is such that the cushion will retain its radially displaced position as a form of "memory" enabling the cushion to return again and again in absolute concentricity within the bore. Clearances between the cushion and its bore are therefore, enabled to be reduced substantially in comparison to prior devices, providing greater cushion efficiency with markedly reduced wear and increased life of the cylinder.

More specifically, in a particular embodiment disclosed herein, the cushion element is carried by the piston rod for insertion immediately prior to the end of the piston stroke into a bore defined by the end cap of a pneumatic or hydraulic cylinder. The outside diameter of the cushion element will sealingly engage the inside wall surface of the bore to prevent further passage therethrough of exhaust fluid which has previously been evacuating from the cushion side of the piston. Between the piston rod and the cushion element is a radial clearance which is equal at least to the total eccentricity which may occur between the axis of the rod and the axis of the cushion bore. The cushion element is held in an axial direction between the face of the piston and a retainer, and intermediate the opposing radial surfaces of the retainer and cushion element I provide a groove for the reception of an O-ring seal. The retainer is normally positioned against the opposing face of the cushion element to compress the O-ring seal with a small axial clearance being maintained between the cushion element and retainer. The forward edge of the cushion element is tapered inwardly to enter the cushion bore and because of the radial clearance provided between the piston rod and cushion element, the latter will be centered during the initial stroke of the piston. The cushion element once centered, retains this position since the O-ring seal maintains a constant engaging pressure between the retainer and the cushion element. Thus, during the initial stroke of the piston, wardly to enter the cushion bore and because of the radial clearance provided between the piston rod and cushion element and will return subsequently during successive strokes into concentric sealing engagement with the cushion bore. This has the advantage of permitting the clearance between the outside diameter of the cushion element and the inside diameter of the cushion bore to be reduced, for example, to .0005 inch whereas clearances previously in conventional cushion designs have been much greater (in the order of .0015 inch to .003 inch).

A further advantage of the foregoing arrangement is that the cushion element itself has a piston area which is exposed to increasing pressure due to the trapping of fluid between the exhaust face of the piston and the end cap of the cylinder. Such pressure increase will urge the cushion axially toward the cushion retainer, thereby further compressing the O-ring seal to increase its sealing effect and to obviate any possibility of the O-ring extruding from its mounting groove.

As mentioned, when the cushion has become seated toward the end of a piston stroke, a quantity of fluid is trapped between the end of the piston and the end cap. This fluid is gradually permitted to bypass to exhaust

and for the control of the bypass passageway an adjustable metering screw is provided.

In accordance with a further aspect of the present invention, a gland nut is disclosed which carries an adjustable metering screw and surrounding the shaft of the screw, a packing disc, back-up washer and a spring washer of the Belleville type in that order. When the gland nut is assembled to the end cap of the fluid cylinder, the spring washer is brought to bear against an internal shoulder within the cylinder cap. The spring washer thereafter will exert a compressive resilient loading upon the back-up washer and upon the packing, with the latter in sealing engagement with the threads of the metering screw and the wall surface of the bore which receives the gland nut. The screw may thereafter be adjusted axially to secure a proper flow of fluid through the metering passage and at all times during such adjustment, the spring washer will exert a sufficient pressure upon the packing which engages the threads of the screw to assure that leakage will not occur.

Yet another aspect of the invention concerns an assembly technique wherein the piston is secured to the piston rod in a novel and advantageous manner. Conventional means have heretofore involved using a one-piece rod wherein the piston is attached thereto by pinning or by making the rod an assembly of two lengths bolted and pinned together with the piston fastened to one of the rods by a common bolting means. Pinning the piston as a method of securing the same to the rod creates a serious strength problem in high thrust or impact applications. Further problems are created when attempts are made to match pistons to existing shafts or vice versa in the repair of fluid cylinders. In the alternative, joining two rods together at the piston introduces concentricity and cost factors as well as a loss of rigidity.

In the new piston-rod assembly disclosed herein, a one-piece piston rod is machined to have a series of radial grooves for receiving respectively, a piston seal and piston retaining elements. One end of the piston is held by a retainer which is split longitudinally for assembly within its groove. A separate groove in the rod receives an O-ring which prevents the leakage of fluid beneath the piston past the piston rod. A third and longer groove in the rod receives a threaded washer, which is split longitudinally and assembled therein. In making the assembly of the piston to the rod the threaded washer and O-ring are first assembled in their grooves, and thereafter, the piston is threaded to the washer until it bottoms. The split washer at the opposite side of the piston is then assembled in its groove and the piston is backed off or reverse-threaded until it bears against the split washer. A sufficient torque is applied to preload the assembly. The piston is then staked to the threaded washer.

In the following description reference is made by way of non-limiting examples, to forms of construction of a fluid cylinder devised in accordance with the invention and illustrated in the accompanying drawing in which:

FIG. 1 is a longitudinal cross-sectional view of a fluid cylinder constructed to include the cushion adjusting feature and metering screw of the invention;

FIG. 2 is an enlarged detailed illustration of the cushion assembly;

FIG. 3 is an enlarged detail of the metering screw; and

FIG. 4 is a second fluid cylinder in which the piston assembly of the invention for double ended rod cylinders has been particularly illustrated.

Referring now to the drawing, a fluid cylinder 10 has been illustrated having end caps 11, 12 which are secured at each end to an intermediate cylindrical body 13. O-ring seals 14, 15 are provided to effect fluid seals at the junctures of the caps and the cylinder body. The cap 12 journals a piston rod 16, one end 16a thereof projecting from the cap 12 for attachment to a device to be operated or moved by the cylinder 10. The cap 12 threadably receives a journal bushing 17 having pressure responsive

seal members 18, 19 for engaging portions of the rod 16 to prevent leakage past the rod from the interior of the cylinder.

A piston 20 is mounted to the rod 16 adjacent the internal end thereof, for reciprocating movement within the cylinder body 13. The piston 20 has pressure responsive seal members 21, 22 for effecting a seal between the periphery of the piston and the interior wall surface of the cylinder body 13 upon the admission of a pressure fluid into the cylinder body 13 for driving the piston. Pressure fluid will be admitted to chambers 23 and 24 alternately through ports 26, 27 in the end caps 12, 11. It will be understood that each of the ports 26, 27 will also serve as an exhaust orifice for evacuating a chamber 23, 24 during one half of a cycle.

In accordance with the invention, the piston rod 16 carries adjacent opposite faces of the piston 20, cushion units designated generally by reference numerals 28, 28'. As best seen in FIG. 2, the cushion unit 28 comprises an outer cushion element 29 and an inner retainer 30. The retainer 30 is threaded to the piston rod 16 and bears against an inner radial face or radial shoulder 31 of the cushion element 29. The radial shoulder 31 also defines a groove 32 for the reception of an O-ring 33. At its left side, the cushion element 29 is brought to bear against a right face of the piston 20 by the axial pressure exerted against the shoulder 31 by the retainer 30. This axial pressure is sufficient to maintain the O-ring 33 in compression to effect the seal while permitting a small axial clearance, to be maintained between the left side of the retainer 30 and the opposing shoulder 31 of the cushion element. Radial clearances 34 and 34a are provided between the inside diameter of the cushion element 29 and the outside diameter of the rod 16 and between the larger inside diameter of the element 29 and the outside diameter of the retainer 30. Such radial clearances permit the cushion element 29 to be shifted radially in accordance with eccentricities which may result between the axis of the rod 16 and the bore which receives the cushion element, as will be further described.

The end cap 11 defines a bore 36 having an area of reduced diameter 36a immediately adjacent to the chamber 24. In accordance with the operation of the invention, when the piston 20 is driven toward the right, for example, by the admission of a pressure fluid through the port 26 and into the chamber 23, fluid in chamber 24 will first be permitted to escape through the bore 36 and therefrom through the port 27. But as the piston nears the end of its stroke, the cushion element 29 will begin to enter the neck or reduced area 36a of the bore 36. Since a normal build up of tolerances in the manufacture of the several internally nesting parts of the device thus far described will normally result in an eccentricity between the axis of the rod 16 and the axis of the bore 36, the cushion element 29 will, in all probability, be at first off-center with respect to the axis of the bore 36. Therefore, when the cushion element 29 first begins to enter the bore 36 the cushion element will be "bumped" in a radial direction in order to center itself within the neck 36a. In order to permit such centering action, the forward end of the cushion element is provided with an inward taper 29a. It will be noted that the centering action is permitted by the radial clearances 34, 34a which are at least sufficient to accommodate any radial eccentricity which may be produced during the normal build up of manufacturing tolerances. It will be further noted, that the axial pressure of the retainer 30 against the O-ring 33 and through the latter's agency against the cushion element 29, will cause the cushion element to be retained in the radially displaced position (with respect to the axis of rod 16) once the centering action has occurred. In other words, the structure provided is in effect a built-in memory system for assuring that after the initial stroke of the piston, the cushion element will thereafter remain centered during succeeding strokes with respect to the bore 36.

The foregoing is of extreme importance since it permits the sealing clearance between the cushion element and the neck 36a to be reduced substantially over devices wherein the cushion element must accommodate an out of alignment condition between the axis of the rod bearing the cushion and the receiving bore. The arrangement described is also an improvement over cushions of the floating type wherein the cushion is merely permitted to float resiliently upon being bumped and forced to accommodate itself to eccentricity alignment since in the latter instance, the cushion element tends to return to its initial out of alignment position once the cushion element emerges from the receiving bore. It will be understood therefore, that in the present arrangement no appreciable wear can occur between the sides of the cushion element 29 and the surrounding sealing surfaces of the bore 36 due to eccentricity of the parts. Furthermore, the location of the O-ring 33 and the minimum clearance provided between the O-ring groove and the left side of the retainer element 30 permits extremely high pressures without extruding the O-ring. This is not the case, for example, in prior art devices which provide O-ring seals about the periphery of a cushion element (or seals within the receiving bore itself) since the clearance which must be maintained in these cases inherently demands low pressure operation or else failure of the O-ring or other seal must occur. In the present embodiment, the cushion device disclosed will successfully operate at pressures up to 10,000 p.s.i.

Another advantageous feature of the present design is that as the cushion element 29 enters the bore 36, thereby permitting pressure to build up within the chamber 24, and the pressure in chamber 24 gradually increases, such pressure will act upon a piston area 29b of the cushion element, forcing the element 29 toward the right and into greater engagement with the retainer 30. This has the effect of further compressing the O-ring 33 and of achieving a greater sealing effect thereby while eliminating any possible danger of O-ring extrusion or blow out.

From an examination of the drawing it will be apparent that the cushion unit 28' will operate in the same manner as has been described in connection with the cushion unit 28. However, in the case of the unit 28', the cushion element 29' is held axially by a retainer 30' which is a split washer received within a groove in the rod 16, instead of by threading the retainer to the rod as was done with the retainer 30.

As the cushion element 29 achieves a seal within the bore 36, the pressure in chamber 24 will increase and provides a gradual decelerating effect against the right face of the piston 20. In order to continue movement of the piston to the end of its stroke, bypass metering passages 38, 39 are provided which conduct fluid from the chamber 24 to the chamber 40 and therefrom through the exhaust orifice 27. On the return stroke, check valves 25 in inlet passages 35 connecting ports 26 and 27 with the chambers 23 and 24, respectively, only one of which is shown in FIG. 1 as connecting the port 26 with chamber 23, permit pressure to increase rapidly against the piston until the cushion elements 28, 28' emerge from their respective bores. The degree of cushioning provided by the cushioning devices 28 and 28' is made variable by means of metering screw devices 41 one of which is shown in FIG. 1 and which comprise a second feature of the present invention.

In accordance therewith, reference is made to FIG. 3 wherein the metering device 41 is shown in detail. The device 41 includes a gland nut 42 which carries a central metering screw 43 having a frusto-conical metering surface 43a at the upper end thereof. The gland 42 further carries a disc shaped packing 44, a retainer washer 46 and a Belleville spring disc washer 47 in succession. The metering screw device 41 is installed within the cap 11 by first threading the gland 42 into a tapped bore at the cap 11 provided for that purpose. The gland 42 will be provided with spanner wrench holes or similar means for

applying torque thereto and will be turned until the gland bottoms against a shoulder 43 in the cap. The spring washer 41 will previously have abutted a second internal shoulder 49 and during the final threading of the gland 42 toward and against the shoulder 48, the washer 47 will exert compressive loading upon the retainer 46 and upon the packing 44. The packing under such compressive force will cold-flow into the thread grooves of the screw 43 thereby effecting a seal and further, will effect a seal about its periphery with the adjacent wall surface of the cap. Satisfactory materials for the packing are harder grades of synthetic rubber and many plastic materials such as nylon and Teflon.

The advantage to the foregoing arrangement is that once the gland 42 has been molded, its position and the relative positions of the members 44, 46 and 47 need not be changed materially in order to effect adjusting movement of the metering screw 43. The latter may be adjusted axially in accordance with metering requirements to vary the flow of fluid in the passages 38, 39 providing the cushion effect desired, and since the washer 47 constantly exerts compressive loading upon the packing 44 the seal between the packing and the threads of the screw 43 will be maintained. Satisfactory sealing after repeated adjustments have been made at varying pressures from vacuum to 10,000 p.s.i.

In accordance with a further embodiment of the invention, reference is made to FIG. 4 in which a second fluid cylinder 50 similar in general to the cylinder of FIGS. 1-3, has been illustrated. Therefore, only those pertinent portions of the cylinder 50 will be described. It will be noted that the cylinder 50 is double rod-ended cylinder, that is, contains piston rod 51 which projects from each end of the cylinder. A feature of the invention pertains to the manner in which the piston is connected to the rod. The rod 51 is a single integral shaft which defines an elongate groove 52 for the reception of an externally threaded washer 53. The washer 53 is split into halves and is assembled by this means into the groove 52. The shaft 51 further defines an O-ring groove 54 for the reception of an O-ring 55 to prevent fluid leakage from one side of the piston to the other past the rod. A third groove 56 is defined in the rod 51 for the reception of a split-ring retainer 57.

The piston 58 is assembled upon the rod 51 in the following manner: First the washer 53 is inserted within the groove 52 and the O-ring 55 within its groove 54. The piston is then brought over the rod and the O-ring and is threaded onto the washer 53. The movement of the piston toward the right is continued until the groove 56 is sufficiently clear to receive the split-ring retainer 57 and then this is inserted. The piston 58 is thereafter backed off toward the left to exert axial pressure against the retainer 57 and the exposed right-hand threaded section of the washer 53 is then staked to prevent return movement of the piston in that direction.

The foregoing are improvements over previous piston mounting arrangements wherein the rod is made an assembly of two lengths bolted and pinned together with the piston fastened to one of the rods by a common bolting means and is also an improvement over merely pinning the piston to a one-piece rod. In the embodiments disclosed, the piston is secured against vibration, and the rod and piston are better able to withstand high thrust or impact.

It will be understood that the foregoing description relates to particular embodiments of the invention and is merely representative. Therefore, in order to appreciate fully the spirit and scope of the present invention, reference should be made to the appended claims, in which.

I claim:

1. In a fluid cylinder having a piston axially movable therein in response to fluid pressure, a piston rod, at least one cushion element connected to said piston rod for movement therewith and a bore defined within at least one end portion of said cylinder for slidably and seal-

ingly engaging one of said cushion elements to provide sealing of exhaust flow through said bore prior to the termination of the stroke of said piston, the improvement which comprises said cushion element being constructed as an elongated generally cylindrical member, said rod projecting concentrically from said piston through said cushion element, said cushion element and rod defining a radial clearance at least equal to any eccentricity between the axis of said rod and the axis of said bore, a retainer secured to said rod spaced axially from said piston, a portion of said cushion element being interposed between said retainer and the face of said piston, said cushion element being free to slide radially with respect to the face of said piston and said retainer, sealing means held in engagement between said retainer and said cushion element in the area wherein radial sliding movement between said element and retainer is permitted, and means for moving said cushion element radially with respect to said bore upon movement of said element into said bore to center said element therein, said retainer being positioned on said rod relative to said cushion element to exert an axial compression loading against said cushion element to hold said element in said centered position when spaced axially of said bore.

2. In a fluid cylinder having a piston, a piston rod, a bore defined by at least one end portion of said cylinder for the passage of fluid to exhaust upon movement of the piston toward said bore, the improvement comprising at least one cushion element connected to said piston rod for movement therewith into slidable and sealing engagement within one of said bores to seal off exhaust flow through said bore prior to the termination of the stroke of said piston. means for moving said element radially in response to eccentrically displaced positions of said element and said rod to position said element concentrically with respect to said bore and means positioned on said rod in engagement with said cushion element for holding said cushion element in said concentric position when said element is in a position spaced axially from said bore.

3. The cylinder according to claim 2 in which said cylinder further defines a bypass passageway communicating with exhaust, and adjustable metering means are provided in said passageway to regulate the flow of fluid to exhaust whereby the deceleration of said piston may be controlled.

4. In a fluid cylinder having a piston, a piston rod, and a bore defined at each end of the cylinder by the end portions thereof for the passage of fluid to exhaust upon movement of the piston toward said bore, the improvement comprising a cushion element connected to said piston rod on each side of said piston for movement therewith into slidable and sealing engagement within one of said bores to seal off exhaust flow through said bore prior to the termination of the stroke of said piston toward said bore, means for moving said element radially in response to eccentrically displaced positions of said element and rod with respect to said bore to position said element concentrically with respect to said bore, means for securing said cushion element in said concentric position, a generally elongate groove in said piston rod, a split externally threaded washer positioned in said elongated groove with one end thereof in engagement with the end of one of said cushion elements that faces said piston, a second groove in said rod axially spaced from said elongate groove, and a longitudinally split retainer positioned in said second groove with one side in contact with said piston and with the other side in engagement with the end of the other cushion element that faces said piston, said piston being threaded over said washer to a position where said piston exerts an axial compressive loading in one direction against said retainer and said washer exerts an axial compressive loading against the wall of said elongate groove and the one

cushion element in the opposite direction to hold said piston rigidly in position with respect to said rod and to urge said cushion elements in opposite directions away from said piston and into operative position.

5. The cylinder according to claim 4 in which the rod defines a third groove intermediate said first and second grooves, and a resilient sealing element is received within said groove in contact with axially disposed inner wall surfaces of said piston to prevent leakage between the opposite faces of the piston past the rod.

6. In a fluid cylinder having a piston and a piston rod, means for attaching said piston to said rod comprising a generally elongate groove defined in said rod, a split externally threaded washer received within said groove, a second groove defined in said rod axially spaced from said first groove, said piston being threaded over said washer, a longitudinally split retainer held in said second groove in contact with said piston, said piston and washer exerting axial compression loading in opposite directions to hold said retainer, piston and washer rigidly in position with respect to said rod.

7. In a fluid cylinder having a piston, a piston rod, and a bore defined at each end of the cylinder by the end portions thereof for the passage of fluid to exhaust upon movement of the piston toward said bore, the improvement comprising a cushion element connected to said piston rod on each side of said piston for movement therewith into slidable and sealing engagement within one of said bores to seal off exhaust flow through said bore prior to the termination of the stroke of said piston toward said bore, means for moving said element radially in response to eccentrically displaced positions of said element and rod with respect to said bore to position said element concentrically with respect to said bore, means for securing said cushion element in said concentric position, a generally elongate groove in said piston rod, a split externally threaded washer positioned in said elongate groove with one end thereof in engagement with the end of one of said cushion elements that faces said piston, a second groove in said rod axially spaced from said elongate groove, and a longitudinally split retainer positioned in said second groove with one side in contact with said piston and with the other side in engagement with the end of the other cushion element that faces said piston, a central bore extending axially through said piston in which said threaded washer is concentrically disposed, means comprising a threaded connection located between the opposite ends of said piston for urging said piston in one direction along the longitudinal axis of said piston rod to exert an axial compressive loading in said one direction against said retainer and said other cushion element and for urging said threaded washer in the opposite direction to exert an axial compressive loading against the wall of said elongate groove and the one cushion element in the opposite direction to hold said piston rigidly in position with respect to said rod and to urge said cushion elements in opposite directions away from said piston and into operative position.

8. In a fluid cylinder having a piston and a piston rod, means for attaching said piston to said rod comprising a generally elongate groove defined in said rod, a split externally threaded washer received within said groove, a second groove defined in said rod axially spaced from said first groove, a longitudinally split retainer held in said second groove in contact with said piston, a central bore extending axially through said piston in which said threaded washer is concentrically disposed, and means comprising a threaded connection located between the opposite ends of said piston for urging said piston and washer in opposite axial directions against said split retainer and one wall of said elongate groove to hold said retainer, piston and washer rigidly in position with respect to said rod.

9. In a fluid cylinder having a piston axially movable therein in response to fluid pressure, a piston rod, at

least one cushion element connected to said piston rod for movement therewith and a bore defined within at least one end portion of said cylinder for slidingly and sealingly engaging one of said cushion elements to provide sealing of exhaust flow through said bore prior to the termination of the stroke of said piston, the improvement which comprises said cushion element being constructed as an elongated generally cylindrical member, said rod projecting concentrically from said piston through said cushion element, said cushion element and rod defining a radial clearance at least equal to any eccentricity between the axis of said rod and the axis of said bore, a retainer secured to said rod spaced axially from said piston, a portion of said cushion element being interposed between said retainer and the face of said piston, said cushion element being free to slide radially with respect to the face of said piston and said retainer, sealing means held in engagement between said retainer and said cushion element in the area wherein radial sliding movement between said element and retainer is permitted, and means for moving said cushion element radially with respect to said bore upon movement of said element into said bore to center said element therein, said cushion element including a piston face disposed to receive pressure in an axial direction for movement of the cushion element toward said retainer upon increasing pressure between said piston face and the end portions of said cylinder, in order to effect increased sealing between said element and retainer.

10. The cylinder according to claim 9 in which said cylinder further defines a bypass passageway communicating with exhaust, and adjustable metering means are provided in said passageway to regulate the flow of fluid to exhaust whereby the deceleration of said piston may be controlled.

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SAMUEL LEVINE, *Primary Examiner*.

FRED E. ENGELTHALER, *Examiner*.