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C. W. COOK ET AL  
HYDRAULIC CYLINDER CUSHION

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2 Sheets--Sheet 1

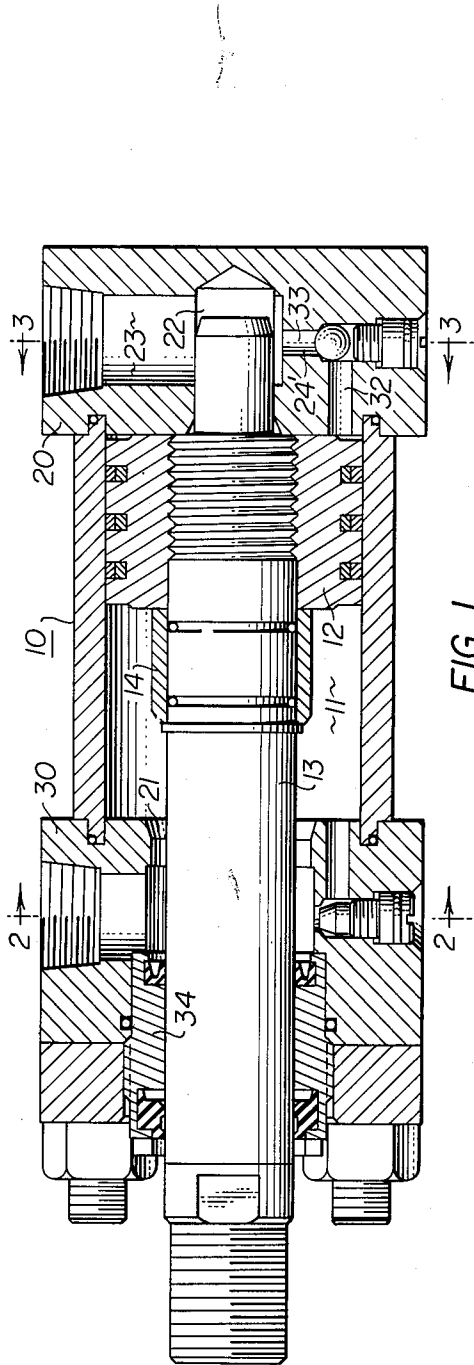


FIG. 1

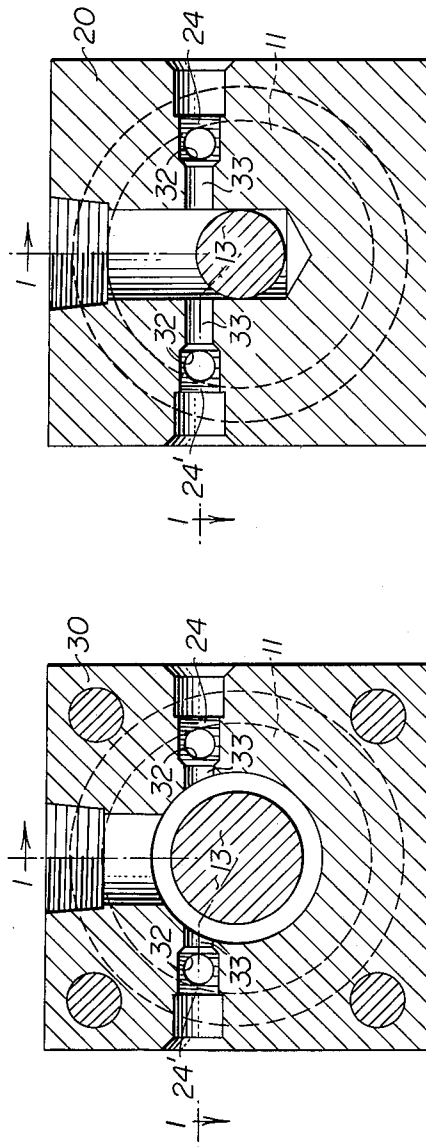


FIG. 3

FIG. 2

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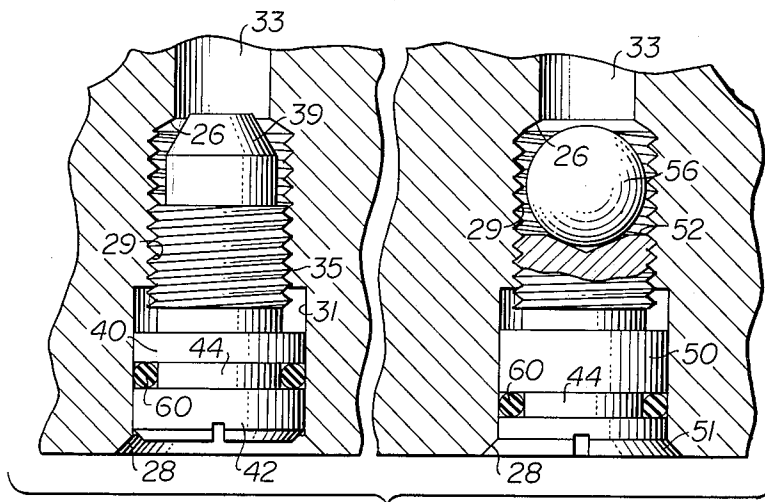


FIG. 4

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## HYDRAULIC CYLINDER CUSHION

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8 Claims. (Cl. 121—38)

This invention relates to fluid power cylinders, and more particularly to the fluid conducting and cushioning systems formed in such cylinders.

The operation of a fluid cylinder is basically a reciprocal motion caused by oil or other fluid under pressure being forced alternately against one side of a piston to drive it in one direction and the other side to drive it back. It is highly desirable to effect a "cushion" of some type at each end of the stroke of the piston. The cushioning is usually effected by restricting the volume of flow of the fluid out of the exhaust side of the cylinder after the piston has completed most of its stroke. Thus, trapped fluid on one side of the piston will cushion its travel at stroke end to prevent its inertia and the load attached to it from driving the piston into the cylinder end with damaging force. This allows a rapid movement over most of the stroke, and a slow movement from which a safe stop can be made at the end of the stroke. It is also desirable to be able to adjust the amount of cushioning; i.e. adjust the rate of escaping fluid flow after the stroke has progressed the predetermined amount. By such adjustment it is possible to obtain optimum efficiency with a minimum of detrimental effect depending on the particular use to which the cylinder is put.

Also, it is desirable to make standard sizes and shapes of cylinder parts, and custom assemble and fit these parts to fill a large variety of needs. It is quite common that the area at the place of installation of a cylinder is quite restricted and access to the cylinder limited from many directions. Thus, the user specifies the desired location of intake and exhaust line attachments, and the location of such devices as mounting means and fluid flow controls. It is highly desirable to have the fluid control adjustment mechanism for the end cushioning in an accessible place so that the cushion adjustment can be accomplished to suit service conditions. For convenience of illustration and description, all reference herein-after will be to an oil hydraulic power cylinder.

One of the principal objects is to provide a versatile fluid conducting system including interchangeable needle valves and check valves for a hydraulic power cylinder.

As an example, one popular type of power cylinder has two square block type head members with a cylinder extending between these end blocks. The head blocks carry the necessary fittings to hold the oil line and are provided with internal channels to direct oil to the cylinder and to conduct exhaust oil from the cylinder. Whenever a cushioned cylinder is specified, auxiliary lines are needed to control a small amount of trapped oil used as a cushion and to permit a bypass influx of oil when a reverse direction stroke is begun. These auxiliary lines are controlled by a needle valve adjustably positioned in the exhaust auxiliary line in order to permit the operator to open or further restrict the exhaust line and control the degree of cushioning effect. A check valve in the line employed to put an initial thrust of oil pressure into the cylinder is needed in order to prevent the cushioning oil from escaping through this inlet auxiliary line. The user specifies the location of the check valve and the needle valve to fit his needs, but it often happens that by error or change of design of the environment equipment, the specified location places the adjustment for the needle valve in an inaccessible location. Use of the cylinder in

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other than its original environment may result in the same concealment of the needle valve adjustment. The operator then must remove the cylinder for adjustment and then reinstall the cylinder for another trial, if the cylinder is not constructed in a manner which will permit the relocation of this adjustment in the field, as set forth in the previous object stating the desired interchangeability of needle valves and check valves. By this arrangement, and the placement of these two valves in diametrically opposed positions, it is seldom that both will be concealed and hence if they are interchangeable, the operator can place the needle valve in the accessible location and move the check valve to the inaccessible location. The check valve needs no adjustment.

Another object of this invention is to provide a fluid conducting system for hydraulic cylinders which can be adjusted for flow volume from one of a plurality of places selectively, which selection can be changed after installation of the cylinder.

A more particular object of this invention is to provide a needle valve for a hydraulic power cylinder which will begin to leak if threaded too far out of its socket, and the leaking will take place suddenly at a definite position, but is securely retained at that leak position against dislodgment under internal oil pressure.

In such adjustable cushion power cylinders, the maximum rate of oil escape after the cushioning effect has taken place is determined by the size of the passage leading from the area of the trapped oil. Hence, adjustment of the needle valve to completely open this passage is the most that can be done to speed up the movement of the cylinder. Nevertheless, the operator is not always able to determine when he has completely opened the passage and may thus over-adjust and cause a needle valve to be completely removed from its chamber with the result that oil can exhaust through the opening and relieve all pressure in the hydraulic system. This may cause personal injury in the event that a high oil pressure is operating through the passage at a time when the inadvertent over-adjustment is made. Hence, according to the foregoing object, if a sudden telltale leakage develops prior to complete release of the needle valve from its socket, the operator will be forewarned that further adjustment is unnecessary and unwarranted.

Expressed a different way, a more particular object of this invention is to provide a needle valve which will retain its position and allow but a slight leak to indicate to the operator that the limit of adjustment has been reached without the valve being forced from the head.

The general discussion and objects hereinbefore discussed have indicated that most needle valve assemblies for such power cylinders are threaded stem members which operate in a threaded socket opening and allow the needle to project into an internal passageway. It is obviously necessary to prevent this threaded needle valve from rotating in its threaded socket and causing a self-adjustment. Many lock washer types of holding devices have been devised and placed in commercial use, but with varying degrees of success. Accordingly, it is a further object of this invention to provide a chamber system and cooperating valve structure which simultaneously provides sealing against leakage and provides a positive drag friction action which will prohibit the unintentional movement of the valve body.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a longitudinal sectional view of a hydraulic cylinder with the end structure at one end taken along a plane indicated by the line 1—1 of FIGURE 2, and the end structure at the other end taken along the plane rep-

resented by the line 1—1 of FIGURE 3, and the central portion a conventional sectional view;

FIGURE 2 is a sectional view of the device of FIGURE 1 taken along the plane indicated by the line 2—2 of FIGURE 1;

FIGURE 3 is a sectional view of the device of FIGURE 1 taken along the plane indicated by the line 3—3 of FIGURE 1; and,

FIGURE 4 is an enlarged detailed view of a needle valve and a ball-check valve assembly.

Referring now to the drawings, a hydraulic power cylinder indicated in general by reference number 10 provides the environment of this invention. The hydraulic cylinder 10 has a conventional tubular form enclosing a chamber 11 in which a piston 12 is free to drive a ram 13. The piston 12 can reciprocate between a first head 20 and a second head 30.

It is in the arrangement of oil flow passages, and controls for the flow through these passages in these heads, that this invention resides.

Head 20 is illustrated as a common conventional type having a block form of square cross section.

A cavity 22 is formed in the head 20, and the end of the ram 13 is shaped to project snugly into the cavity, as shown in FIGURE 1. A main fluid channel 23 extends from one face of the head 20 to the ram seating cavity 22. Oil under pressure is introduced through the channel 23 and the exhaust oil is conducted out of the channel 23, according to the operative direction. However, for cushion construction, the end of the ram 13 is designed to enter into the cavity 22 before all of the oil is exhausted from the chamber in front of the piston and hence some of the oil is trapped. This is the oil that provides the cushioning effect for the ram. Were it not for this trapped oil, the piston would be driven into the head 20 at full operative force by the oil entering in the opposite side of the piston, and by the inertia of the machinery or other driven equipment which is connected externally to the ram and possibly exerting a force in the direction of movement. A fluid such as oil is only slightly compressible and hence an absolute trapping of oil would also produce an impact. For this reason, there is provided a bypass escape duct 24 from the chamber 11 into the channel 23 for the gradual evacuation of the trapped oil, but at a rate of speed slower than the evacuation which took place prior to the entry of the ram into the cavity 22.

Likewise, when the cavity 22 is blocked by the extension of the ram, were it not for a by-pass feeder, oil introduced into the cylinder through the channel 23 would act only on the small area of the ram extension and would not be able to reach the piston 12 and exert any operative force on it.

Hence, a second duct 24' is provided from the cavity 22 into the chamber 11 in order to permit an initial amount of oil to bypass the blocked cavity and reach the chamber 11. Each duct is formed identically so but one will be described and the other, along with the corresponding parts will be referred to when necessary as the primes of the same number. Each duct has one leg 32, extending parallel to the axis of the chamber, and in communication with the chamber. Another leg 33 extends normal to the axis of the chamber and in communication with the cavity 22. Each duct includes a tapered valve seat 26 formed in the leg 33. The valve seat is adapted to coact with either a needle valve stem to regulate the flow of oil or the ball of a ball type unidirectional valve.

The head 30 is substantially identical to the head 20 in all material respects concerning this invention. The head 30 has a through opening and a packing gland 34 to enable the work delivery end of ram 13 to extend from the cylinder. A cavity 21 surrounds the ram and serves as a main supply conduit corresponding to the function of the cavity 22 in the head 20. An annular shoulder 14 carried by ram 13 is proportioned to fit closely with respect to the cavity 21 and block the flow of fluid into the cavity

21 and therefore provides the oil trapping cushion as described with respect to the head 20.

In FIGURES 2 and 3 it will be seen that the valves are placed on opposed side faces of the heads 20 and 30. It must be emphasized that these valves may be placed on any face and the only requirement is that they provide surface access for housing a valve member insert which insert is projectable into the supply line for controlling the flow of fluid through that supply line. In the event that the design of the power cylinder specifies that both of the valve members be placed on one face, much of the advantage, by reason of the exchangeability of a needle valve or ball check valve in either of the bores 29 is lost. If the face from which two such openings extend is placed in an inaccessible location, the exchange of valve positions will not solve the problem. However, whenever the valves are placed on separate surface positions, such for example as illustrated in FIGURE 3, then if one of the valve positions is selected as the needle valve location and the other as the ball check and it is later found that these position selections are undesirable, then because of the illustrated and described bore shape and the cooperating structure of the valve members to be described hereinafter, the valve members are merely shifted in location, and the needle valve, which must be periodically adjusted, is located in the more accessible position. With this background description of the reason for the exchangeability feature, the actual construction of the valve inserts to go into the valve bores, which further enhances this interchangeability and provides the further objects of the invention will now be more readily understandable.

At the juncture between the legs 32 and 33 of the ducts, axially of the valve seats 26, is an extension bore 29 in which a needle valve 40 or the stem of a ball check valve assembly 50 may reside interchangeably. The shape of these bores and the shape of the corresponding valve members residing in the bores is of considerable importance with respect to the new advantages provided by this invention. Each bore has a threaded wall segment 35, and a smooth wall counterbore 31 of larger diameter, and a chamfered entrance wall 28. The valve members are provided with a threaded portion to engage the segment 35 and with an enlarged smooth wall portion having an encompassing O-ring assembly, to act as a seal and as a retarding device providing a positive retarding action preventing accidental threadable adjustment of the valve members.

As best illustrated in FIGURE 4, a needle valve 40 and a ball check bolt 50 have certain structural features which are identical, and others which are deliberately at variance, and all of which are related to the size and shape of the valve bores 29 for the purpose of this invention.

Reference to FIGURE 4 of the drawings will illustrate the similarities and differences of the members 40 and 50 with relationship to the identical bores 29. Referring first to the ball check bolt 50, it will be seen that it is provided with a chamfered top portion 51 corresponding in size and shape to the chamfered wall 28. Thus, the bolt 50 can be turned into the bore 29 only until the chamfer top 51 is seated into the chamfered wall 28. The bolt 50 differs from the needle valve 40 in that the end of the body 50 is short enough to permit movement of the ball 56 between the end of the body 50 and the valve seat upon which the ball can seat. Valve 40 has a needle end 39. When the ball check valve assembly is fully inserted into the bore 29, and the ball is against the end wall 52 of the bolt 50, there is ample room for oil to pass through the duct. When the ball is seated on a valve seat, no fluid can pass through the chamber and the cavity through the duct in which it is seated. In some prior practice, it has been the custom to provide a spring behind the ball check, such as the ball 56, to hold the ball seated against the cavity seat. It has been

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found, however, that by a proper dimension of a distance between the end of the bolt 50 and the valve seat, that the fluid movement through the conduit will lift the ball and cause the ball to seat even though the apparatus is turned in a position to normally allow the ball 56 to fall away from the valve seat by gravity, as shown in FIGURE 4. However, the use of a chamfered top 51 on the bolt 50 enables a positive placement of the bolt 50 in any selected bore 29 when the bores 29 are made all of the same form as taught by this invention. Thus, by accurately locating the end wall 52 with respect to the top surface of the chamfered top 51, the distance between wall 52 and the seat in the bore 29 is accurate and reproducible regardless of which bore 29 the bolt 50 may be seated into. This construction therefore enables the accurate interchangeability of the bolt 50 with any of the bores 29 in the apparatus without concern about accurate spacing of the end wall 52 from its associated ball check seat.

The needle valve 40, on the other hand, has no chamfered top, but rather has only the barrel portion 42 and hence may be threaded into the bore 29 as deep as the end needle construction 39 will permit. Thus, the operator has an immediate visual identification means to determine which of the members is the needle valve and therefore subject to adjustment, and which is the ball check bolt and therefore permanently seated. Heretofore, the difference was not readily apparent by visual inspection and supposed adjustment of a needle valve was sometimes applied to a non-adjusting ball check bolt with disturbing results.

As previously stated, O-ring seals to prevent leakage are old and well known. A very novel and useful modification of the use of O-rings for sealing purposes has been accomplished in this invention. The annular groove 44 around the barrel portions of the valves 40 and 50 are provided to hold O-rings 60. However, the cross-sectional area of the groove 44 is of less total square-inch area than a cross-section area of the O-ring 60. Thus, the reaction force between the O-ring 60 and the counterbore 31 is considerably greater than needed for normal sealing purposes. Reference to technical data provided for the use of O-rings will indicate that such O-rings are intended to be placed in grooves considerably larger in area than the O-ring, and of only sufficient depth to provide a sealing pressure between the O-ring and the chamber into which it is placed.

The purpose of this construction is to obtain a very positive rotational resistance to prevent adjustment of either valve member by vibration of the associated equipment. Heretofore, various types of lock devices have been employed for such purpose or a structure is employed which must be threaded to clamp tightly against the packing. By the provision of wedging an oversized O-ring into an undersized cavity, the valve members are rotatable by inserting a screwdriver into the slotted end of the valve members. Rotation by such a screwdriver is not a free movement. A very definite force must be applied to obtain the rotation, and hence the operator is well aware of the fact that he is producing an adjustment. Naturally, the O-ring also produces an excellent seal to prevent oil leakage past the ring. Nevertheless, the valve member is immediately adjustable at any time without first loosening any holding or locking device, and without the use of any special tool whatsoever, only a screwdriver. The seal and the rotational drag remains intact in all positions and after adjustment of a valve to a selected position, no further step is needed to then secure the valve in that adjusted position.

The chamfered wall 28 has been described as a means for determining the maximum inward position of the chamfered top 51 on the bolt 50. This wall is also employed for the purpose of achieving the insertion of the oversize ring 60 into the undersized groove 44. In the illustration of the preferred embodiment of the invention,

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this chamfered wall 28 is shown at about a 45-degree angle with respect to the axis of the bore 29. This 45-degree angle is a compromise from the theoretical perfect for the purpose of inserting the O-ring. Were it not for the chamfer, the O-ring could not possibly be inserted as illustrated and described because a sharp corner will cut into the O-ring and destroy its sealing properties. Attempts have been made to put such a ring past threads, for example, with disastrous results.

A very small amount of taper will be insufficient to guide the ring 60 into the groove 44 and as a practical matter about a 10-degree chamfer has been found to be quite adequate and ideal for a  $\frac{1}{16}$  inch depth chamfer portion to the bore 29. However, as stated before, the selected angle has been a 45-degree angle for the reason that the angle permits easier machining of the chamfer itself and permits a much more sturdy and reliable construction for the chamfered top 51 of the bolt 50. The taper of 45 degrees is more than the most desirable chamfer with respect to inserting the O-ring 60, but it is serviceable up to about this 45-degree angle.

This invention has been described in the environment of a conventional type of fluid cylinder and is believed to teach the construction and operation of a new cooperative combination wherein identical valve bores are provided at all valve seats and a unique general construction of the valve members embodying a threaded portion and a barrel portion permits the telltale leak creation without attendant danger of ejection of the valve member from the bore, and the further concept of the use of an O-ring too large for its receiving groove in order to accomplish sealing and positive adjustment retention of the valve body. Additionally, the bore is provided with a chamfered opening for the dual purpose of enabling the actual accomplishment of an oversize O-ring in an undersize groove and to provide a positive seat for one of the special valve members in order to enable a positive placement of a ball check seat.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. In a cushion hydraulic cylinder having opposed head ends each with a main fluid port and two bypass oil cushion control passageways, the provision of a valve seat in each bypass passageway, a substantially identical bore from each seat to an external surface, said bore having a threaded cylindrical portion at said seat, the bore also including a smooth walled enlarged counterbore portion within each head and a chamfered surface from said counterbore to said surface, an adjustable valve member engageable in a selected one of said bores, said adjustable valve member having a threaded stem engageable in said threaded cylindrical bore portion of the one bore to provide longitudinal position adjustment of said adjustable valve member, the valve member having an enlarged cylindrical head portion positioned in said counterbore portion of the one bore, and a resilient band encompassing said head portion and compressed between said valve member head portion and the internal wall of said counterbore portion of the one bore to provide fluid sealing and anti-rotational drag preventing unintentional rotation of the valve member, and a fixed position ball check bolt having a threaded stem portion engageable in said threaded cylindrical bore portion of the other bore, said bolt also having an enlarged cylindrical head portion positioned in said counterbore portion of the other bore, said bolt including a chamfered head mateable to the chamfered bore surface, and a resilient band encompassing said bolt head portion and compressed between said bolt

head portion and the internal wall of said counterbore portion of the other bore to provide fluid sealing and anti-rotational drag preventing unintentional rotation of the bolt.

2. In the structure of the valve member and bore of claim 1, the depth of said counterbore and longitudinal position of the band encompassing said head portion being related to the length and location of the threaded portion to provide full retention engagement of said thread prior to sealing engagement of the band into the counterbore.

3. An adjustable valve and bore housing combination, comprising, a body member having a fluid passageway therein with a valve seat in said passageway, the body member including a valve housing bore from said seat to an opening at the exterior of said body member, said bore having a smooth wall section adjacent said exterior opening and extending from a first inner end to a second outer end at said exterior opening, a valve body member threaded in said bore, said valve body member having a smooth wall section fitted within said bore smooth wall section and extending from a first outer end to a second inner end, one of said smooth walls in one of the members having surfaces defining an annular groove therein, an O-ring in said groove, said groove having a cross-sectional area less than the cross-sectional area of said O-ring, whereby said O-ring produces a high frictional drag but allows relative rotational movement of the valve body in said bore without loss of sealing characteristic during such movement, and the other of the members having a chamfered portion at its first end flaring from the first end of the other of the wall sections.

4. In the combination as defined in claim 3, said bore member is said other member having a chamfered wall at said first end at said surface and said valve body member is the one member with a groove formed therein.

5. In the combination as defined in claim 4, said valve body having a needle end to cooperate with said valve seat, and said smooth wall section having a cylindrical form extending to a top surface, whereby the body is longitudinally adjustable without respect to said chamfered wall and the chamfer produces a visible annular groove around the valve body.

6. In the combination as defined in claim 4, said valve body member second end having a chamfered outwardly extending shoulder portion matable with said bore chamfer wall to limit the inward movement of the body member and define the relative position of valve body member and seat.

7. In a cushion hydraulic cylinder having opposed head ends each with a main fluid port and two bypass oil cushion control passageways, the provision of a valve seat in each bypass passageway, a substantially identical bore from each seat to an external surface, each such bore having a threaded cylindrical portion adjacent said seat, each bore also including a smooth-walled enlarged counterbore portion within each head communicating with each threaded portion and extending from a first outer end to a second inner end, an adjustable valve member engageable in a first one of said bores, said adjustable valve member having a threaded stem portion engageable in the threaded cylindrical bore portion of the first bore to provide longitudinal position adjustment

of said adjustable valve member, said adjustable valve member including a first enlarged cylindrical head portion positioned in said counterbore of the first bore and extending from a first inner end to a second outer end, and a resilient band encompassing said first head portion and compressed between said first head portion and the inner wall of the first bore counterbore portion of the first bore to provide fluid sealing and anti-rotational drag preventing unintentional rotation of the valve member, and a fixed position ball check bolt member having a threaded stem portion engageable in the threaded cylindrical bore portion of the second bore, the bolt member having a second enlarged cylindrical head portion positioned in the second of said counterbore portions and extending from an inner first end to an outer second end, a resilient band encompassing said second head portion and compressed between said second head portion and the internal wall of the second counterbore to provide fluid sealing and anti-rotational drag preventing unintentional rotation of the bolt, one of the first portions including a chamfered part at its first end and the corresponding one of the second portions including a chamfered part adjacent its first end, said chamfered parts each camming the associated resilient band into position between the like numbered portions on insertion of a valve member in a bore.

8. A valve construction comprising, a body having an internal fluid passageway and a communicating bore;

said bore extending from an outer wall on the housing inwardly;

said bore including a threaded portion adjacent the inner end thereof, and a smooth-walled, cylindrically-contoured counterbore portion outwardly from the threaded portion and contiguous to and axially aligned with the threaded portion;

a valve member including a threaded portion engaged with the bore threaded portion;

the valve member also including a cylindrically contoured head portion within the counterbore and having an O-ring groove in the head portion and within the cylindrical contour;

an O-ring in the groove and of greater cross-sectional area than the groove;

said O-ring being squeezed between the groove and the counterbore portion in tight frictional engagement; and,

the axial distance from the groove to the member threaded portion being greater than the axial distance from the outer end of the bore threaded portion to the outer end of the counterbore portion whereby when the valve member is backed out of the bore the O-ring will emerge from the counterbore portion prior to the disengagement of the threaded portions.

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