This invention relates to internal combustion engines and more particularly to valve operating push rod assemblies therefor.

The principal objects of the present invention are: to provide an hydraulic push rod assembly adapted to eliminate push rod adjustments for running clearance after the engine has been installed in service, to provide such an assembly which automatically compensates for changes in temperature which tend to adversely lengthen or shorten valve operating push rods; to provide such a device which automatically compensates for wear on valve faces and valve seats by lengthening or shortening as necessary to maintain optimum valve closure conditions, to provide such a push rod assembly which reduces the shock load normally transmitted between the cam shaft and valve via the push rod so as to reduce the possibility of fatigue failure of affected engine parts; to provide such a device which operates hydraulically but requires no external source of hydraulic fluid; to provide such a push rod assembly wherein hydraulic cushioning fluid is self reclaimed; and to provide such an assembly which is simple in construction, inexpensive to produce, and highly reliable for its intended purpose.

Other objects and advantages of this invention will become apparent from the following description taken in connection with the accompanying drawings wherein are set forth by illustration and example certain embodiments of this invention.

FIGURE 1 is a fragmentary view in side elevation of an internal combustion engine particularly showing a push rod between the cam shaft and the valve head which constitutes an hydraulic valve push rod assembly embodying this invention.

FIGURE 2 is a sectional view taken longitudinally through the push rod assembly and on an enlarged scale particularly showing the interior structure thereof.

FIGURE 3 is a cross-sectional view taken on the line 3—3 of FIGURE 2 particularly showing the oil reclaiming passageways of the push rod assembly.

FIGURE 4 is a cross-sectional view taken on the line 4—4 of FIGURE 2 particularly showing the fluid cushioning by-pass passageway and ball cage cavity of the push rod assembly.

Referring to the drawings in more detail:

The reference numeral 1 indicates generally a large internal combustion engine in the illustrated example, of the type commonly manufactured by the Worthington or Cooper Bessemer Corporation and known as a "horizontal engine," although the invention herein is equally effective on engines of the "vertical" type. The engine 1 includes a cylinder assembly 2 having a cooling jacket 3 extending therearound in the well known manner. The engine 1 has a cam shaft 4 which rotates in synchronization with the piston reciprocal and carries fixed thereto a cam 5. The cam 5 is maintained in contact with a cam roller 6 operatively connected to a valve push rod 6. The rotation of the cam 5 causes a periodic generally axial displacement of the push rod 6 which results in the reciprocation of a rocker arm 7 for operating a cylinder valve (not shown).

An hydraulic valve push rod assembly 8 embodying this invention forms a part of the push rod 6 and is as described below. The push rod assembly 8 comprises an elongated rigid cylindrical casing 9 having an upper end 10 and a longer end 11. The casing 9 has a blind bore 12 extending upwardly and longitudinally thereinto from the lower end 11 and is adapted to receive a lower portion 13 of the push rod 6. A pair of set screws 14 extend laterally into and are threadedly engaged with the casing 9 adjacent the blind bore 12 for securing the push rod lower portion 13 against longitudinal displacement with respect to said casing.

The casing 9 has an internal wall 15 forming an elongated piston recoiling cylinder 16 extending longitudinally thereinto from the upper end 10. The cylinder 16 includes a lower chamber 17 and an intermediate chamber 18 and an upper chamber 19 which are intercommunicating and mutually co-axial. The lower chamber 17 and upper chamber 19 preferably are of greater diameter and of shorter length than the intermediate chamber 18 the surface of which cooperates with a piston surface as later described. The lower chamber 17 has a blind bottom 20.

A cylindrical piston 21 is received in the cylinder 16 and is of slightly smaller diameter than the intermediate chamber 18 forming a clearance or tubular shaped conduit 21' therewithin whereby the piston outer surface 22 slidably cooperates with the wall 15 at the intermediate chamber and fluid, described hereinafter, is able to flow therebetween. The piston 21 has an upper end 22' and a lower end 23 and an interior including coaxial upper and lower chambers 24 and 25 respectively communicating with each other. The piston lower chamber 25 is of larger diameter than the piston upper chamber 24 forming a piston shoulder 26 therewithin. The piston lower chamber 25 has threaded walls 27 and the piston upper chamber 24 has a top portion 28.

A check valve seat member 29 is contained in the piston lower chamber 25 and has a downwardly facing valve seat cavity 30 and a diameter larger than the piston upper chamber 24. The check valve seat member 29 has a passageway 31 much greater in cross-sectional area than the conduit 21' communicating between the valve seat cavity 30 and the piston upper chamber 24. A ring gasket 32 is located between and abuts the piston shoulder 26 and the seat member 29.

An externally threaded retainer member 33 is threadedly engaged with the threaded wall 27 of the piston lower chamber 25 and abuts the check valve seat member 29 for urging the ring gasket 32 into sealing contact with the seat member 29 and the piston shoulder 26. The end of the retainer member 33 abutting the seat member 29 has a peripheral bevel that forms a groove 33'. The retainer member 33 has an upwardly facing ball cage cavity 34 therein having by-pass ducts 34' and a passage way 35 communicating between the ball cage cavity 34 and the cylinder lower chamber 17. The cross-sectional or flow area of the ducts 34' and the passageway 35 is much greater than the conduit 21'. The ball cage cavity 34 is aligned with and adjacent the valve seat cavity 30 forming a check ball retaining enclosure 36.

A check ball 37 is loosely contained in the enclosure 36 and is adapted to reciprocate vertically to alternately engage the valve seat cavity 30 and the ball cage cavity 34 to alternately prevent fluid flow upwardly through the seat member passageway 31 and permit fluid flow downwardly therethrough.

An annular groove 38 surrounds the piston 21 and is enclosed by the wall of the intermediate chamber 18. A laterally extending passageway 39 extends into the piston 21 and into the retainer member 33 and communicates between the groove 38 and the ball cage cavity 34.

A plurality of bores 40 extend radially and laterally into the piston 21 and form passageways 40' communicating between the cylinder upper chamber 19 and the
piston upper chamber 24. An annular cap 41 is secured to the upper end 10 of the casing 9 by means of longitudinally extending cap screws 42 extending therethrough and threadedly engaging the casing 9. The cap 41 surrounds the piston 21 and has an inside bore orifice 43 with a diameter smaller than the cylinder upper chamber 19 forming a cap shoulder 44 facing the cylinder upper chamber.

A snap ring groove 45 surrounds the piston 21 and supports a snap ring retainer 46 extending radially outwardly into the piston 21 and into the cylinder upper chamber 19. The snap ring retainer 46 is adapted to 44 interfere with the cap shoulder 44 to prevent excess upward movement of the piston 21 with respect to the casing 9.

An internal groove 47 extends into the inside surface 44 of the cap 41 and supports an O-ring seal 48 in contact with the outer surface 22 of the piston 21. A washer 49 is clamped between the heads of the screws 42 and the cap 41 and retains the O-ring seal 48 in the groove 47 during upward motion of the piston 21 with respect to the casing 9.

An elongated bore 50 extends axially upwardly from the top portion 28 of the piston upper chamber 24 and into the body of the piston 21. A laterally extending bore 51 communicates between the atmosphere and the bore 50 to provide a venting passageway 52 extending between the piston upper chamber 24 and the atmosphere outside the piston 21.

The lower end 53 of the push rod upper portion 54 in the illustrated example is a diameter substantially equal to the diameter of the piston 21 at the upper end 22. A sleeve 55 has an internal diameter substantially equal to the diameters of the upper end 22 and push rod lower end 53 for axially receiving the piston and end 53 in abutting relation as illustrated in FIGURE 2. A set screw 56 extends laterally into the sleeve 55 and is threadedly engaged therewith for securing the sleeve 55 to the lower end 53. The sleeve 55 is adjusted with respect to the lower end 53 so that a portion of the sleeve extends below the push rod upper portion 54 forming a socket 57 for conveniently axially receiving the piston upper end 22.

A helical compression spring 58 is contained in the lower chamber 17 and bears respectively on the piston lower end 23 and the cylinder lower chamber bottom 20 and engages the piston 21 upwardly with respect to the casing 9 and into the socket 57. An hydraulic fluid 59 such as a suitable oil is contained in the piston upper chamber 24 preferably at a level between the piston upper chamber top portion 28 and the piston shoulder 26, submerging the checkball 37.

In operation, a compressive force between the push rod upper portion 54 and the push rod lower portion 13 overcomes the spring 58 causing a quantity of the fluid 59 to be compressed in the cylinder lower chamber 17. The compression produces a fluid flow upwardly through the passageway 35 urged by the checkball 37 into seating engagement, the valve seat cavity 30 prohibiting upward fluid flow through the passageway 31. The fluid 59 contained in the cylinder lower chamber 17 is forced to bypass the passageway 31 and flow through the passageway 39 into the annular groove 38. The fluid then flows in small quantities from the groove 38 upwardly through the convention 33 and the wall of the intermediate cylinder 18 and enters the cylinder upper chamber 19. The fluid contained in the cylinder upper chamber 19 which rises above the level of the bores 40 flows therethrough into the piston upper chamber 24. A very small quantity of the fluid 59 may enter into the groove 38 directly from the cylinder lower chamber 17 by fluid flow between the piston and cylinder walls but this quantity is generally not significant.

The relaxing of the compressive force permits a lowering of fluid pressure to a negative quantity with respect to the atmosphere due to the action of the spring 58. This unseats the check ball 37 and permits rapid reverse fluid flow through the passageways 31 and 35 and into the cylinder lower chamber 17 to complete the cycle. It is to be understood that the small clearance between the piston 21 and the wall of the intermediate cylinder 18, forming the conduit 21', permits upward flow at a desired slow or leakage rate whereby only a small relative movement between the piston and the casing 9 is permitted during the short interval when valve opening pressure is applied to the push rod 6. This small relative movement, however, provides a cushioning effect to reduce shock loading which would otherwise be transmitted between the cam shell 12 and the cylinder lower chamber 18 which forms the upper surface of the groove 38 has a relatively sharp edge 61 at the periphery thereof forming a wiping edge which tends to further restrict and stabilize the flow characteristics of the groove 38 and conduit 21'. In a typical installation the difference in diameter between the wall of the intermediate cylinder 18 and the piston is in the nature of .002 inch for a piston in the nature of two inches in diameter. After running a few cycles the piston and the casing assume a floating position with respect to each other which produces the desired closing and opening conditions for the valve (not shown) controlled by the rocker arm and tappet and valve closure noises and the engine stresses accompanied thereby.

The hydraulic valve push rod assembly 8 automatically compensates for changes in temperature which tend to lengthen or shorten the push rod 6 and change the most desirable valve opening and closing positions. The assembly 8 will also automatically compensate for wear on valve faces and valve seats and other variables which tend to alter proper running clearances for valves after the engine is placed in operation. Valve guide and stem wear and breakage are reduced due to the even force transmission through the assembly 8 and improved valve timing produces fuel savings. It is to be understood that the valve assembly 8 is operated with the casing upper end 10 spaced upwardly from the casing lower end 11 a degree sufficient to cause hydraulic fluid to flow downwardly into the piston upper chamber 24 without losing fluid through the venting passageway 52. Once charged with hydraulic fluid the assembly 8 is completely self contained and requires no fluid addition except for minor losses due to evaporation. Since the piston 21 substantially floats on a film of oil within the casing 9, under normal conditions of operation wear is practically non-existent over long periods of engine operation. The controlled alteration in clearance between the piston and casing has a direct relation on the speed of relative change of position therebetween during the periodic compressive loading of the push rod 6 and the assembly 8 can be adjusted in this manner to provide the most desirable engine operation.

The installation of the assembly 8 does not require the removal or alteration of any of the engine parts except a central portion of the push rod. The use of controlled clearances between the piston and the casing eliminates the need for a packing gland, reducing the cost and the complexity of the device. The assembly 6 contains only 3 moving parts, namely, the piston, check ball and spring and after proper installation requires no mechanical adjustment. It is to be understood that the characteristics of the spring 58 are matched with the clearance between the piston and casing to provide a cooperation therebetween whereby the fluid is pulled through the passageways 31 and 35 at a rate which permits the spring to maintain the push rod 6 under some compressive load ever with the instant of maximum upward acceleration thereof. It is to be further understood that while one form of this invention has been illustrated and described it is not to be limited to the specific form or arrangement of parts herein described and shown except insofar as such limitations are included in the claims.
What I claim and desire to secure by Letters Patent is:

1. A shock absorbing and self adjusting compressive force transmitting device comprising:
   (a) a rigid casing having an upper end and a lower end,
   (b) said casing having an internal wall forming a piston receiving chamber extending thereinto from said upper end and closed at the bottom thereof,
   (c) a piston in said piston receiving chamber and slidably cooperating with said wall,
   (d) clearance between said piston and said wall forming an upwardly extending fluid conduit,
   (e) said piston having an upper end and a lower end and an interior including upper and lower chambers communicating with each other, said piston upper chamber having a top portion,
   (f) a check valve seat member secured in said piston lower chamber and having a downwardly facing valve seat cavity and a passageway of greater cross-sectional area than said fluid conduit and communicating between said valve seat cavity and said piston upper chamber,
   (g) means preventing fluid flow between said piston upper and lower chambers except through said seat member passageway,
   (h) a retainer member secured adjacent said seat member and having an upwardly facing ball cage cavity and a passageway of greater cross-sectional area than said fluid conduit and communicating between said cage cavity and said piston receiving chamber below said piston, said ball cage cavity being aligned with and adjacent said valve seat cavity forming a check ball retaining enclosure,
   (i) a check ball loosely contained in said enclosure and adapted to reciprocate to alternately engage said valve seat cavity and said cage cavity to alternately prevent fluid flow upwardly through said seat member passageway and permit fluid flow downwardly therethrough and through said retainer passageway with substantially less restriction than through said fluid conduit,
   (j) a return passageway in said piston and communicating laterally between said cylinder upper chamber and said fluid conduit,
   (k) a groove in the outer surface of said piston and encased by said wall,
   (l) a groove feeding passageway in said piston and providing communication between said groove and said ball cage cavity,
   (m) resilient means adapted to urge said piston upwardly with respect to said casing, and
   (n) an hydraulic fluid in said piston receiving chamber with said piston and submerging said check ball,
   (o) whereby a compressive force between said piston upper end and casing lower end which overcomes said resilient means causes fluid to be compressed in said piston receiving chamber and seat said ball in said valve seat cavity and flow through said fluid conduit upwardly and enter said piston chamber through said return passageway, and a relaxing of said compressive force unseats said ball and permits fluid to flow downwardly through said retainer member passageway and into said piston receiving chamber below said piston.

2. A shock absorbing and self adjusting force transmitting device comprising:
   (a) an elongated rigid cylindrical casing having an upper end and a lower end,
   (b) said casing having an internal wall forming an elongated piston receiving cylinder extending longitudinally therinto from said upper end,
   (c) said cylinder including lower and intermediate and upper intercommunicating and mutually coaxial chambers, said cylinder upper chamber having a greater diameter than said cylinder intermediate chamber, said cylinder lower chamber having a blind bottom,
   (d) a cylindrical piston in said cylinder and slidably cooperating with said wall,
   (e) clearance between said piston and said wall forming an upwardly extending tubular fluid conduit,
   (f) said piston having an upper end and a lower end and an interior including coaxial upper and lower chambers communicating with each other, said piston lower chamber being of larger diameter than said piston upper chamber forming a piston shoulder therebetween,
   (g) said piston upper chamber having a top and said piston lower chamber having a threaded wall,
   (h) a check valve seat member in said piston lower chamber and having a downwardly facing valve seat cavity and a diameter larger than said piston upper chamber and a passageway of greater cross-sectional area than said fluid conduit and communicating between said valve seat cavity and said piston upper chamber,
   (i) a ring gasket abutting said piston shoulder and said check valve seat member,
   (j) an externally threaded retainer member threadedly engaged with said piston lower chamber threaded wall and abutting said check valve seat member for urging said ring gasket into sealing contact with said seat member and piston shoulder,
   (k) said retainer member having an upwardly facing ball cage cavity and a passageway of greater cross-sectional area than said fluid conduit and communicating between said cage cavity and said cylinder lower chamber, said ball cage cavity being aligned with and adjacent said valve seat cavity forming a check ball retaining enclosure,
   (l) a check ball loosely contained in said enclosure and adapted to reciprocate to alternately engage said valve seat cavity and said cage cavity to alternately prevent fluid flow upwardly through said seat member passageway and permit fluid flow downwardly therethrough and through said retainer passageway with substantially less restriction than through said fluid conduit,
   (m) an annular groove surrounding said piston and enclosed by the cylinder wall forming said intermediate chamber, a laterally extending passageway communicating between said groove and said ball cage cavity,
   (n) at least one return passageway communicating between said cylinder upper chamber and said piston upper chamber,
   (o) a compression spring in said cylinder lower chamber and bearing respectively on said piston lower end and said cylinder lower chamber bottom and urging said piston upwardly with respect to said casing, and
   (p) an hydraulic fluid in said cylinder with said piston and submerging said check ball,
   (q) whereby a compressive force between said piston upper end and casing lower end which overcomes said spring causes fluid to be compressed in said cylinder lower chamber and seat said ball in said valve seat cavity and flow through said fluid conduit and enter said piston upper chamber through said return passageway, and a relaxing of said compressive force unseats said ball and permits fluid to flow downwardly through said retainer member passageway and into said cylinder lower chamber.

3. The device of claim 2 wherein:
   (a) a shoulder forms the upper surface of said groove, and including
   (b) a sharp edge at the periphery of said shoulder forming a wiping edge.
4. A shock absorbing self adjusting compressive force transmitting device comprising:
   (a) a cylinder having an open upper end and a closed lower end,
   (b) a piston fitting in said cylinder and providing an hydraulic chamber in said cylinder below said piston, said piston having an upper end extending outwardly of said cylinder upper end,
   (c) a closure secured to said cylinder at said upper end thereof and surrounding said piston to provide a central aperture in which said piston reciprocates,
   (d) seal means in said closure and slidably engaging said piston in fluid-tight relation,
   (e) stop means on said piston for engaging said closure to limit movement of said piston from said cylinder,
   (f) said piston having a bore extending axially therein from the lower end thereof,
   (g) a downwardly facing valve seat in said bore and defining a fluid reservoir thereabove,
   (h) a retainer member adjacent said valve seat and defining a valve cage cavity and a passageway communicating between said cage cavity and said hydraulic chamber,
   (i) a check valve in said cage cavity and adapted to move to alternately engage said valve seat and said retainer to alternately prevent fluid flow upwardly through said valve seat and permit fluid flow downwardly therethrough,
   (j) a return passageway in said piston and communicating laterally between the cylinder adjacent the closure and the fluid reservoir in the piston,
   (k) a circumferential groove in said piston,
   (l) a passageway laterally through the piston communicating said groove with the cage cavity below said valve seat,
   (m) and means urging said piston outwardly of said cylinder whereby a compressive force moving the piston inwardly of the cylinder causes fluid to be compressed in the hydraulic chamber and said check valve and a relaxing of said compressive force unseats the check valve and permits fluid to flow from the reservoir through the valve seat to the hydraulic chamber.

5. The device of claim 4 including,
   (a) a port in said piston extending from an exteriorly opening end above said closure to the upper end of the fluid reservoir to vent said reservoir to the atmosphere,
   (b) and the means urging the piston outwardly of the cylinder is a spring in said cylinder hydraulic chamber bearing on the piston and the closed lower end of the cylinder.

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