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Langland

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[54] **CUSHIONED HYDRAULIC ACTUATOR**

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[51] **Int. Cl.** **F15b 15/22**

[58] **Field of Search** ..... 91/404, 405, 406, 407, 91/25, 26, 24, 31; 92/143; 251/117 X; 137/596.2 X

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Assistant Examiner—Abraham Hershkovitz
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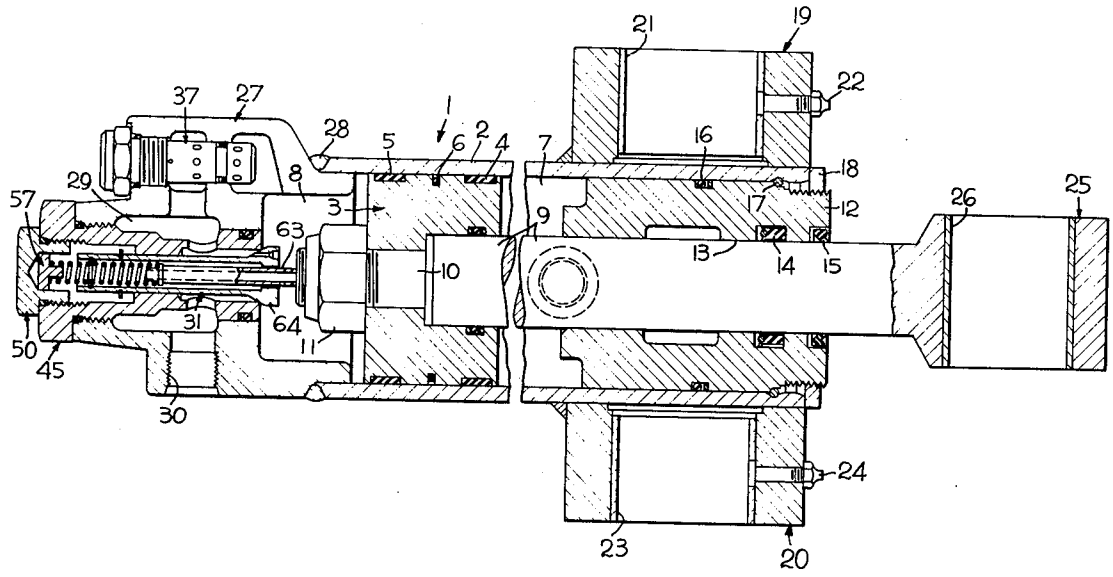
[57] **ABSTRACT**

A hydraulic cylinder having a reciprocating piston and cushioning means on the end of the cylinder to decelerate the piston as it comes to the end of its stroke. The decelerating means includes a valving means and orifice means to restrict the flow and produce throttling of the hydraulic fluid as the piston nears the end of its stroke.

10 Claims, 3 Drawing Figures



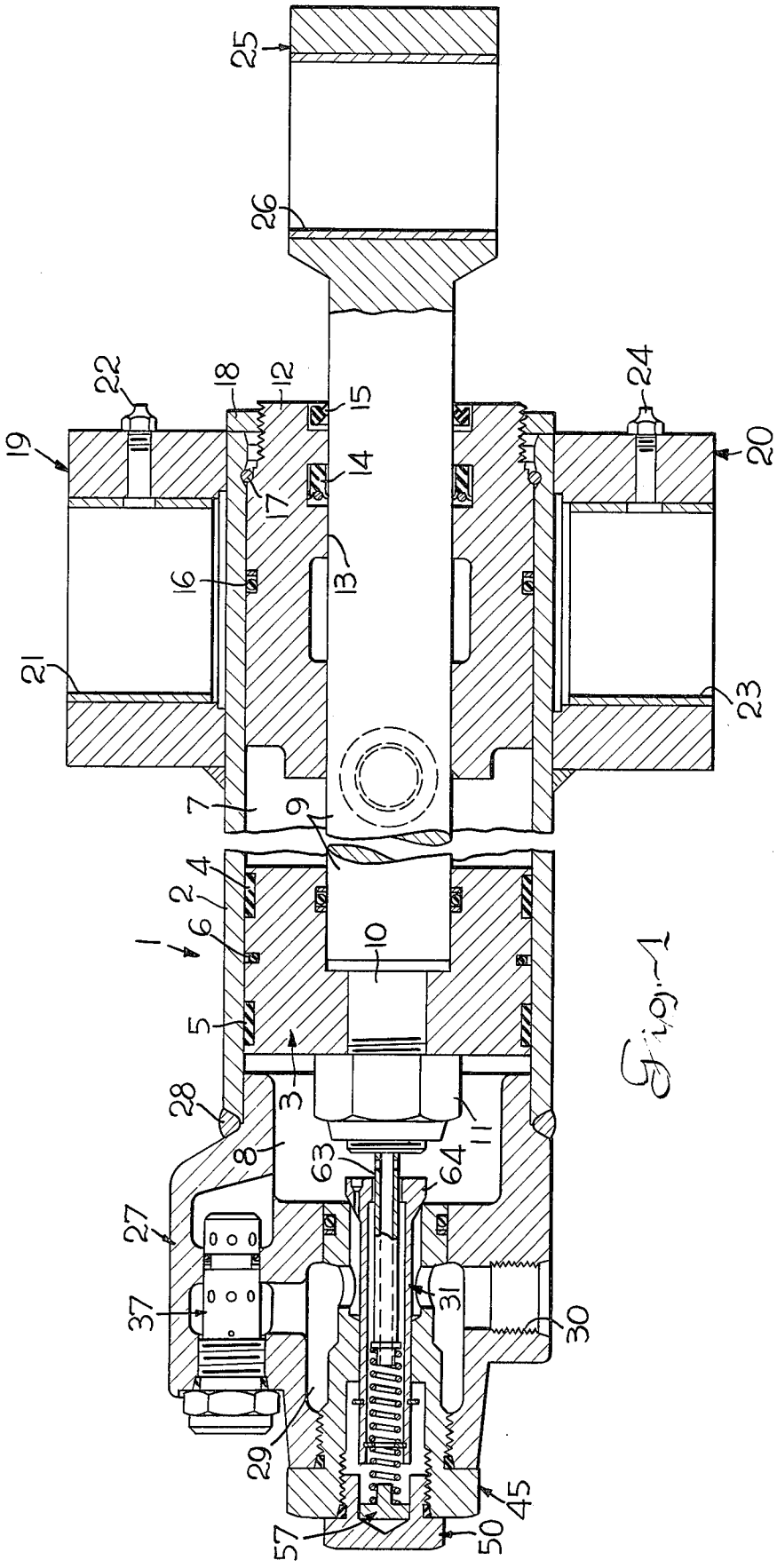

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Fig. 1

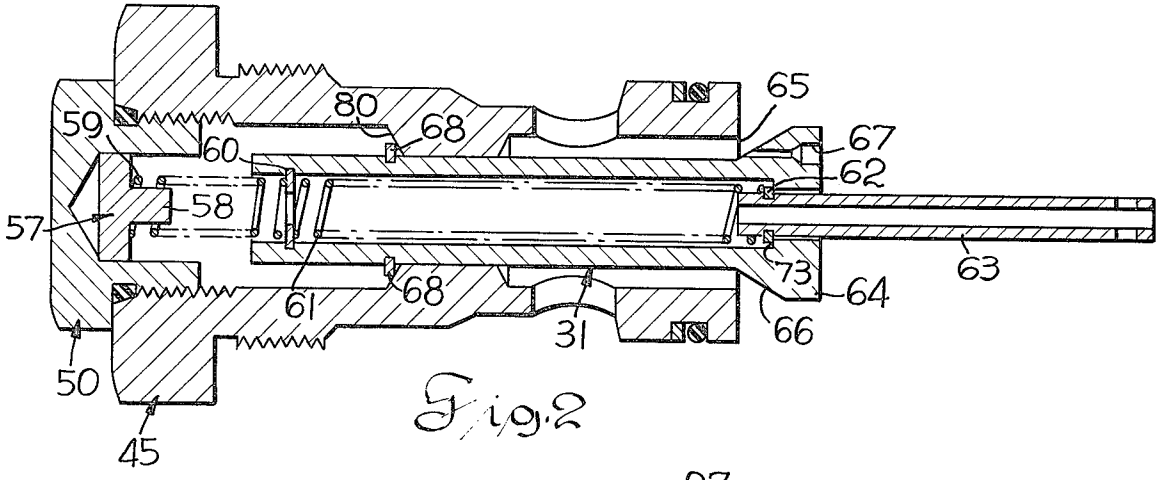
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Fig.2

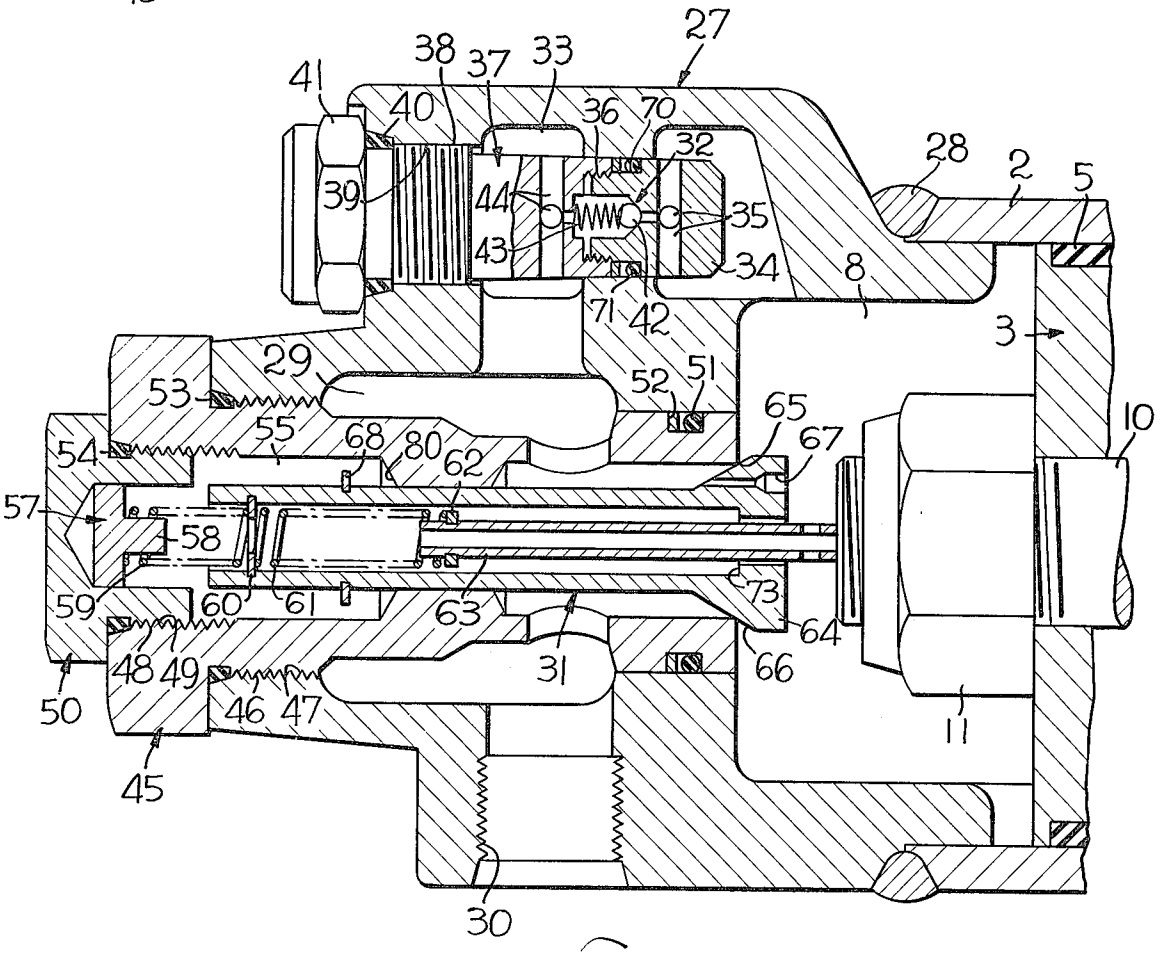
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Fig.3

CUSHIONED HYDRAULIC ACTUATOR

This invention relates to a hydraulic cylinder and more particularly to a cushioning means to decelerate the movement of the piston as it nears the end of its stroke.

Hydraulic cylinders are used to perform a number of operations in hydraulic systems used on motor vehicles. Most of the hydraulic cylinders carry a substantial load and during their operation are subjected to inertia forces. This is particularly true of the hydraulic cylinder as it nears the end of its stroke. The load carried by the hydraulic cylinder is often so great that if the load were allowed to force the piston unrestrained to the end of its stroke in the hydraulic cylinder, it may cause irrepairable damage to the cylinder. Shock loading of this type cannot be tolerated in the hydraulic system not only because it may damage the hydraulic cylinder but the load itself may be subjected to excessive inertia forces.

Accordingly, this invention provides a means whereby inertia forces normally produced by the load on the hydraulic cylinder at the end of the piston stroke are substantially reduced or eliminated to prevent damage to the hydraulic cylinder and to provide smooth operation of the hydraulic system in handling the load carried by the hydraulic cylinder. The cushioning means in the hydraulic cylinder is accomplished through throttling of the hydraulic fluid as the piston nears the end of its stroke. The throtting is produced by a valve which is actuated by the piston to close a valve and force fluid through an orifice or a check valve to eliminate the shock and inertia forces suddenly imposed on the hydraulic cylinder as it reaches the end of its stroke.

It is an object of this invention to provide a cushioned hydraulic cylinder or hydraulic actuator for decelerating the movement of the piston near the end of its stroke.

It is another object of this invention to provide a cushioned hydraulic cylinder for decelerating the movement of the piston near the end of its stroke with a cushioning means in a removable cartridge to permit removal of the cartridge for easy repair and servicing.

It is a further object of this invention to provide cushioning means in a hydraulic actuator for throttling the hydraulic fluid through a closing poppet valve in the end of the hydraulic actuator, an orifice, and a check valve to prevent shock loading and high pressures in the hydraulic chamber as the piston nears the end of its stroke.

It is a further object of this invention to provide a cushioned hydraulic actuator to decelerate the piston movement as it nears the end of its stroke by throttling through a closing poppet valve, an orifice, and check valve and to limit high pressures and eliminate high inertia forces as the piston comes to the end of its stroke.

The objects of this invention are accomplished by providing throttling means in the end of a hydraulic actuator which throttle the fluid as it is discharged from the hydraulic actuator near the end of the piston stroke. The cushioning means includes a poppet valve and orifice in the head of the hydraulic actuator which can be readily removed for servicing and repair to keep the cushioning means in the best of operating conditions. Together with the poppet valve and an orifice, a check valve is also provided to eliminate any shock or

inertia forces from damaging the end of the hydraulic actuator as the piston nears the end of its stroke and particularly when the hydraulic actuator is under a loaded condition.

The preferred embodiment of this invention is illustrated in the attached drawings.

FIG. 1 is a cross-section view which illustrates an hydraulic actuator with a cushioning means.

FIG. 2 is an enlarged cross-section view which illustrates a removably cartridge for operation as a cushioning means in the hydraulic actuator of FIG. 1 with the poppet valve open.

FIG. 3 is an enlarged cross-section view of the end of the hydraulic actuator shown in FIG. 1 with the poppet valve in closed position and the piston near the end of its stroke.

Referring to the drawings, FIG. 1 shows the hydraulic actuator in cross section. The hydraulic actuator **1** includes a cylindrical housing **2** encasing a piston **3** carrying the seals **4** and **5** and a ring **6** for sealing the hydraulic fluid between the chambers **7** and **8.** The piston **3** is connected to a piston rod **9** by means of a bolt end **10** and nut **11.** The piston rod extends through the end wall **12** which has a cylindrical opening **13** which receives the seals **14** and **15** to seal the chamber **7** of the external side of the hydraulic actuator.

The end wall **12** is also provided with a seal **16** on an external periphery engaging the internal periphery of the cylindrical housing **2.** The snap ring **17** locks the assembly against an internal force and an external nut **18** threadedly engages the end of the wall **12** to lock assembly against the cylindrical housing **2.**

The cylindrical housing **2** is also fabricated to the trunnion bearings **19** and **20.** The trunnion bearing **19** includes the bearing shell **21** having an opening for receiving lubricant through the grease fitting **22.** The trunnion bearing **20** is also fitted with a bearing shell **23** and a similar grease fitting **24** for lubrication of the trunnion bearing **20.**

The piston rod **9** includes a bearing end **25** which receives the bushing **26** which is adapted for connection to a shaft for carrying the external load on the hydraulic actuator **1.**

The hydraulic actuator **1** includes a head **27** which is welded at **28** to the cylindrical housing **2.** The head **27** together with the piston **3** and the cylindrical housing **2** forms the expansible chamber **8.** The head **27** also forms a valve chamber **29** which is in communication with the flow port **30** adapted for connection to a source of fluid. The flow of fluid through the port **30** may be of high pressure to extend the piston and expand the chamber **8** or of a low pressure fluid when the fluid is discharged from the expansible chamber **8** through the poppet valve **31.**

A check valve **32** is also contained within the head **27.** The check valve **32** is contained within the compartment **33** and includes the valve seat **34** which has cross passages **35** for receiving fluid from the expansible chamber **8.** The valve seat **34** has a threaded portion **36** which threadedly engages the valve support **37** which in turn has a threaded portion **38** which threadedly engages a threaded opening **39** in the head **27.** A suitable seal **40** is provided underneath the head **41** of the valve support **37.** The valve support **37** carries the valve seat **34** and can be removed as a unit from the head **27** if servicing is desired. The check valve **32** includes a ball **42** and spring **43** normally biasing the

check valve to a closed position. Suitable passages are provided to transmit fluid from the cross passages **35** in the valve seat **34** to the cross passages **44** in the valve support **37** which provide communication between the expansible chamber **8** and the compartment **33.**

The check valve **32** is formed with a peripheral groove **70** to receive the seal **71** to seal the expansible chamber **8** from the valve chamber **29.**

The poppet valve **31** includes the valve body **45** having a threaded portion **46** which threadedly engages a threaded opening **47** in the head **27** and is removable as a valve cartridge. The valve body **45** also is provided with a threaded interior **48** which threadedly receives the threaded portion **49** of the cap **50.** A seal **51** is received within the annular recess **52** to provide a seal between the expansible chamber **8** and the valve chamber **29.** The seal **53** between the valve body **45** and the head **27** seals the chamber **29** from the exterior side of the head while the seal **54** provides a seal between the cavity **55** and the exterior side of the hydraulic actuator.

The spring seat **57** is seated within the cap **50** and has a stem **58** received within the spring **59.** The spring **59** is compressibly positioned between the spring seat **57** and the retainer ring **60.** Similarly a spring **61** is compressibly positioned between the retainer **60** and the snap ring **62** carried on the plunger **63.** The poppet **64** is slidably positionend within the valve body **45** and normally biased to the open position as shown in FIG. **2.** The valve body **45** forms a valve seat **65** which engages a conical surface **66** when the poppet valve is in the closed position as shown in FIG. **3.**

The poppet forms an orifice **67** providing communication between the valve chamber **29** and the expansible chamber **8** when the poppet valve **31** is in the closed position.

The snap ring **68** provides a stop to limit the open position of the poppet valve **31.**

The operation of the cushioning means will be described in the following paragraphs.

When the hydraulic actuator is in operation and the piston **3** is in a position remote from the head **27,** the poppet **64** is spring biased outwardly by the spring **59** compressed against the retaining ring **60** which engages the inner periphery of valve body **45.** The plunger **63** is spring biased outwardly by the spring **61** compressively positioned between the retaining rings **62** and **60.** With the plunger and the poppet in the extended position oil can flow freely from the expansible chamber **8** to the valve chamber **29.**

As the piston moves near the end of its stroke it contacts the plunger **63.** The poppet **64** then becomes unbalanced due to the load induced by the plunger spring **61.** As the poppet **64** moves toward the spring retainer **57** the oil in expansible chamber **8** assists the spring in forcing the poppet **64** to seat on the valve seat **65** of the valve body **45** due to the pressure drop caused by a reduced outlet area in the poppet valve **32.** After the poppet **64** has seated on the seat **65** oil can be exhausted through the orifice **67** in the poppet **64** or through the relief valve **32.** Normally the relief valve opens after the poppet has seated. Relief valve **32** then reseats. The remaining oil is forced through the orifice **67.** When the poppet seats on the seat **65** of the valve body **45** the plunger **63** will continue to retract through the remainder of the piston stroke and the load against the springs **61** remains as the resilience of the spring allows for this overtravel. The piston stroke is such that the piston rod **9** stops short of the striking of the poppet **64.**

To extend the piston rod **9** and the piston **3** in the hydraulic actuator hydraulic fluid flows through the flow port **30** into the valve chamber **29** opening the poppet valve **31** and flowing into the expansible chamber **8.** The oil pressure unseats the poppet valve **31** expanding the plunger springs **61** as the oil enters the expansible chamber **8** through the valve. As the piston rod moves with the piston **3** the piston **3** moves out until the retaining ring **62** engages the radical flange **73** of the poppet **64.** As the piston **3** and rod **9** move to the extended position within the hydraulic actuator the poppet **64** of the poppet valve **31** fully opens with snap ring **68** engaging surface **80** of valve body **45.** The plunger **63** within the poppet **64** extends to its fully extended position and fluid flows freely through the flow port **30,** the valve chamber **29** and the poppet valve **31** into the expansible chamber **8.**

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A hydraulic actuator comprising a cylindrical housing, a head fastened to the end of said cylindrical housing defining a valve chamber communicating with a flow port, a piston slidably received within said cylindrical housing and forming an expansible chamber with said head, a removable valve cartridge mounted in said head including a valve body defining a valve seat, a valve element slidably mounted within said valve body and defining a poppet valve with said valve seat in said body, fastening means on said head and valve cartridge removably fastening said valve cartridge in said valve chamber said valve cartridge controlling fluid flow between said expansible chamber and said valve chamber conduit means through said valve body interconnecting the internal and external portions thereof, means defining an orifice providing restrictive fluid passage across said poppet valve and communicating said expansible chamber with said valve chamber via said conduit means, a relief valve, means supporting said relief valve in said head and passage means within said head communicating said expansible chamber with said relief valve and further passage means within said head communicating said relief valve with said valve chamber to limit peak pressures in said expansible chamber, resilient means interposed between said valve body and said valve element normally biasing said valve element to an open position, a valve actuating plunger, resilient means interposed between said valve element and said plunger, said plunger engaging said piston to close said poppet valve and provide restrictive fluid flow through said orifice when said piston nears the end of its stroke and thereby cushioning the movement of the piston by restricting the flow of fluid from said expansible chamber.

2. A hydraulic actuator as set forth in claim **1** including, a relief valve casing housing said relief valve and fastening means removably supporting said relief valve casing in said head.

3. A hydraulic actuator as set forth in claim **1** wherein said relief valve defines a ball check valve, means removably fastening said relief valve in said head, said relief valve providing relief of peak pressures in said expansible chamber when said piston nears the end of its stroke.

4. A hydraulic actuator as set forth in claim 1 wherein said valve element defines said orifice.

5. A hydraulic actuator as set forth in claim 1 including a spring normally biasing said plunger to an extended position for engaging said piston when said piston nears the end of its stroke.

6. A hydraulic actuator as set forth in claim 1 wherein said valve actuating plunger defines a hollow plunger, means defining a central opening in said valve element for reciprocally receiving said plunger, ports means in said plunger for transmitting fluid from said central opening in said valve element when said plunger is biased by said piston to close said valve.

7. A hydraulic actuator as set forth in claim 1 where said fastening means, includes said valve body defining a cylindrical sleeve including a threaded portion, and means defining a cylindrical opening in said head having a threaded portion for receiving said cylindrical sleeve.

8. A hydraulic actuator as set forth in claim 1 including said relief valve positioned in said head to permit fluid flow only from said expansible chamber to said valve chamber to limit peak pressures in said expansible chamber when said piston nears the end of its stroke.

9. A hydraulic actuator as set forth in claim 1, said head including means centrally supporting said valve cartridge in said hydraulic actuator.

10. A hydraulic actuator as set forth in claim 1 wherein said valve body defines a sleeve, said valve element defines said poppet valve mounted within said sleeve, said poppet valve defines said orifice whereby said orifice and said poppet valve control the flow to and from said expansible chamber in said hydraulic actuator.

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