April 14, 1964 E. L. THOMPSON ETAL 3,128,885

LONG TRAVEL HYDRAULIC CUSHION DEVICE

Filed Oct. 23, 1961 2 Sheets-Sheet 1

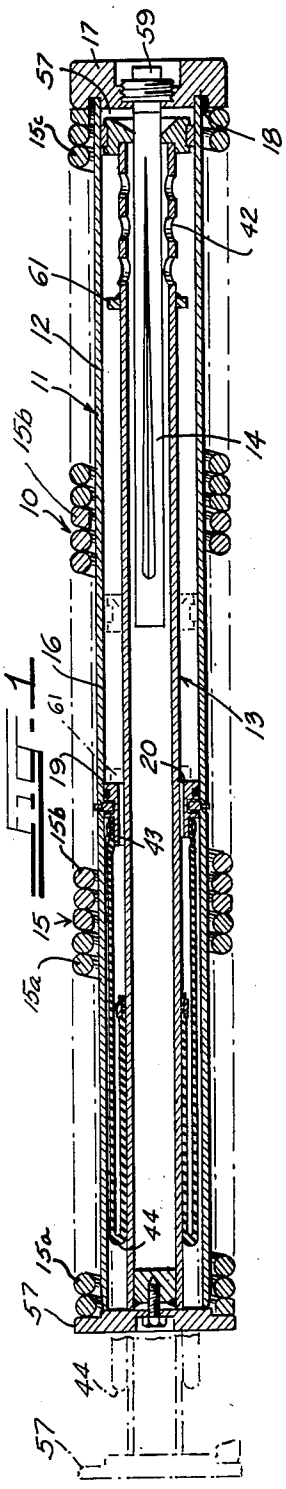


FIG. 1

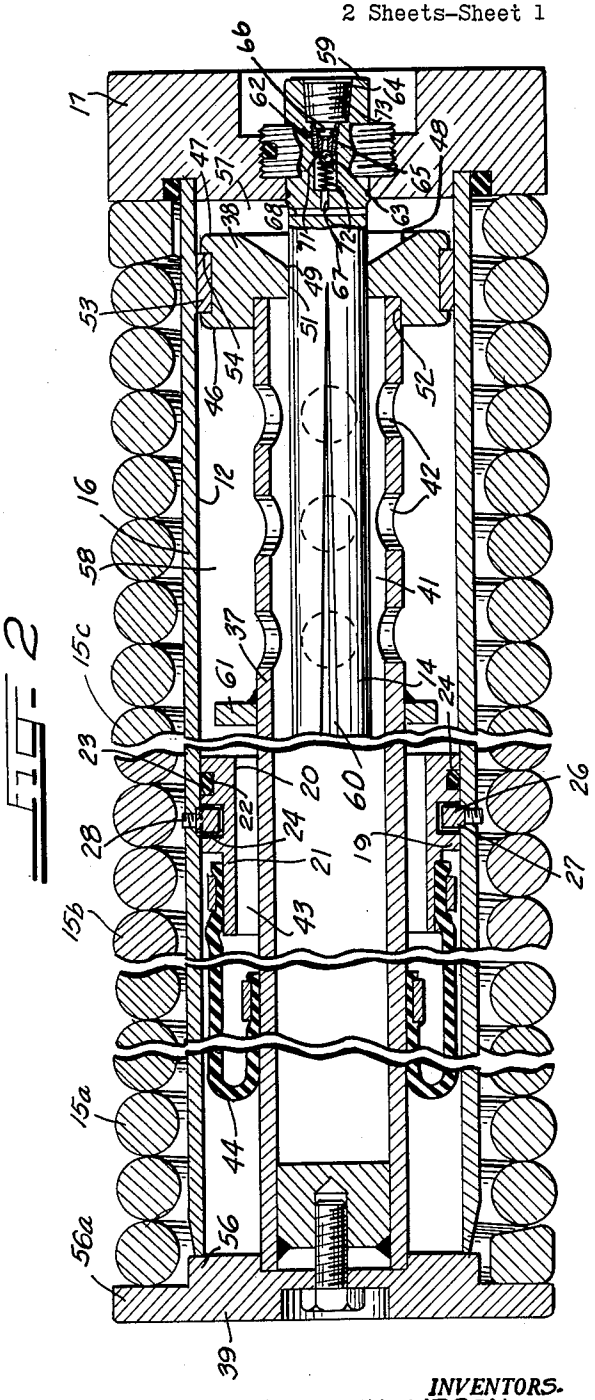


FIG. 2

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FIG. 4

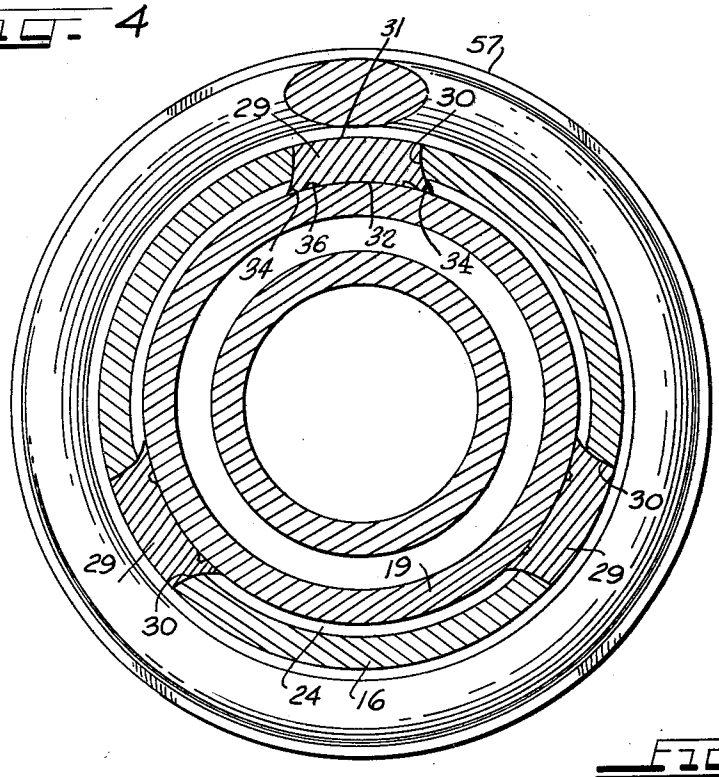


FIG. 5

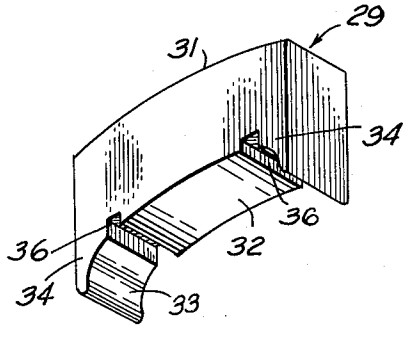
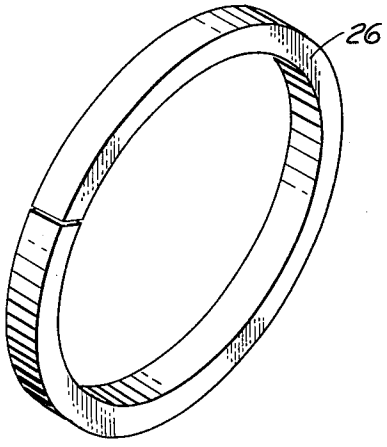


FIG. 3



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LONG TRAVEL HYDRAULIC CUSHION DEVICE

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The present invention relates to hydraulic cushion devices and more particularly to an improved cushioning device of the type comprising basically two relatively telescoping components having arranged therebetween hydraulic fluid which is operative upon the application of a force on the components to dissipate the kinetic energy.

A cushioning device of the above type embodying the general principles is disclosed in U.S. patent application, Serial No. 856,963, filed December 3, 1959, now U.S. Patent No. 3,003,436, and U.S. patent application, Serial No. 782,786, filed December 24, 1958, now U.S. Patent No. 3,035,827, both assigned to the assignee of the present invention. These applications relate to a new and novel method and structure for providing a long travel cushioning arrangement achieving force-travel cushioning characteristics which are equivalent to travels of the substantially constant force type.

It is the primary object of the present invention to provide an improved cushioning device structure constructed and arranged in a manner to facilitate the ready assembly and disassembly of the interior cylinder head incorporated therein.

It is still a further object to provide means fixing the interior cylinder head by way of a keying arrangement insertable from the exterior of the cylinder in which the cylinder head is mounted.

It is still another object to provide a keying arrangement including a key movable by means located exterior of the cylinder from a keying position to hold the cylinder head fixed within the cylinder to a non-keying position whereby the cylinder head is axially movable within the cylinder.

Further objects and features will hereinafter appear.

FIG. 1 is a small scale longitudinal section of the cushioning device embodying the present invention and shown in full lines in its fully contracted position and by the phantom lines in its fully extended position.

FIG. 2 is an enlarged fragmentary section of the device in its fully contracted position as shown in FIG. 1 and showing one form of the present invention for keying the cylinder head to the cylinder.

FIG. 3 is a perspective view of the key employed in the keying arrangement of FIGS. 1–2.

FIG. 4 is a cross-sectional view of the cushion device showing a further embodiment for keying the cylinder head within the cylinder.

FIG. 5 is a perspective view of one of the keying elements employed in the embodiment of FIG. 4 prior to being inserted.

Referring now to FIGS. 1 and 2, there is shown a cushioning device 10 embodying the present invention including generally a cylinder 11 having a bore 12 charged with a suitable hydraulic fluid; a fluid displacement means 13 telescopingly arranged relative to the cylinder 11 between a fully extended position as shown by the phantom lines of FIG. 1 to a contracted position upon the application of a shock force applied to the device and being operative upon contraction to displace fluid within the bore 12 to dissipate kinetic energy in the form of heat; a metering pin 14 for controlling the rate of displacement of the fluid within the bore to provide substantially constant force-travel cushioning characteristics to the device; and a resilient means 15 disposed between the fluid displacement means and the cylinder for returning the members to their fully extended position upon dissipation of the shock.

The cylinder 11 includes a tubular shell formed preferably from a rigid metallic, preformed tube 16 capable of withstanding internal pressures without buckling, such as cold-drawn steel tubing of which the inner wall surface is sufficiently smooth to permit efficient operation of the fluid displacement means 13 disposed therein. It has been found that the smoothness ordinarily obtained by the conventional polished mandrel method of forming steel tubing is satisfactory. However, it is to be understood that a surface formed in any other manner having substantially the same smoothness characteristics may also be employed.

The tube or shell 16 is closed at one end by a cylinder head 17 having a groove 18 formed therein for receiving one end of the tube and the latter is fixed therein as by welding to form a leak-proof joint. The cylinder head 17 is of somewhat larger diameter than the diameter of the shell so as to provide a flange engaging one end of the resilient spring-means 15 encompassing the cylinder.

Located between the cylinder head and the free end of the tube is a second cylinder head 19 preferably formed from steel tube or the like and includes an axial bore 20, a hub 21, and a peripheral recess 22 for receiving an O-ring 23 and a circumferential groove 24 providing a keyway. If desired the cylinder head 19 may be formed from solid block material and fabricated to form the structure shown.

For the purpose of facilitating the assembly and, if necessary, the removal of the cylinder head 19 within the shell 16 in accordance with the present invention there is provided a novel keying arrangement which permits the fixing of the cylinder head without having to work within the confines of the cylinder bore.

In one form of the keying arrangement as shown in FIGS. 1–3 there is employed a split, expandable ring 26 which serves as a key selectively positionable within a keyway 27 formed in the inner wall of the cylinder and the keyway 24 of the cylinder head 19. The expandable key 26 is preferably formed of a spring steel and is sized so that when contracted, the upper surface thereof lies flush with the outer surface of the hub, i.e., the keyway 24 is of sufficient depth to accommodate the thickness of the key.

For selectively positioning the split or snap ring key into its keying position as shown in the full lines or to its unkeyed position as shown in the phantom lines there is provided key seating or positioner means which in the embodiment illustrated includes a plurality of radially spaced screws 28 threadable into the tube 16 and in alignment with the keyway 24.

For fixing or keying the cylinder head 19 to the tube 16 the screws 28 are retracted out of the cylinder keyway 27. The key 26 is positioned in the cylinder head keyway 24 and contracted so as to be slidable within bore 12. Thereafter, the cylinder head is moved within the cylinder until the key aligns with the cylinder keyway 27 whereupon the ring expands and seats in its keying position.

For positioning the key to release the cylinder head, the screws are threaded inwardly to bear on and contract the key 26 so that it lies wholly within the cylinder head keyway. In this position of the key, the cylinder head may be axially moved and removed from the free end of the tube 16.

In another form of the invention, as shown in FIGS. 4

and 5, the cylinder is formed with radially spaced slots **30** into each of which there is inserted a key **29** of the type shown in FIG. 5. Each of the keys **29** is dimensioned so as to be snugly received within the slots **30** and is formed with an upper surface **31** having a radius substantially the same as the radius of the outer diameter of the tube. The lower surface is formed with an intermediate surface **32** having a radius substantially the same as the radius of the bottom wall of the keyway **24** and at each end with a surface **33** of smaller radius defining a pair of ear-like projections **34** at either end of the key. Transverse slots **36** are provided to separate the ear-like projections **34** from the intermediate surface **32**.

To assemble the cylinder head **19** in the tube **16** the keyway **24** is located in alignment with the key slots **30** and the keys **31** inserted therein. The keys **31** are then forced as by hammering or the like so that the ear-like projections spread outwardly from the slots and are wedged between the inner wall of the tube **16** and the bottom wall cylinder head keyway **24** so as to securely fix the cylinder head in position.

Disassembly of the cylinder head **19** and tube **16** is readily accomplished by merely splitting each of the keys **29** between its ends such as by a chisel. Thereafter the split halves of the key may be slipped out from their wedging position whereby the cylinder head is freely movable within the tube for removal therefrom.

The fluid displacement device includes a piston rod **37** to one end of which there is connected a piston head **38** which is reciprocable within the bore between the cylinder heads **17** and **19** and to the other end of which there is connected a closure plate **39**.

The piston rod **37** includes a bore **41** and may be formed of a rigid metallic material, such as cold-drawn steel tubing, and is provided adjacent the piston head **38** with a plurality of radially spaced ports **42** for providing communication between the cylinder bore **12** and the piston rod bore **41**.

To preclude metal-to-metal contact, the outer diameter of the piston rod **37** is substantially less than the diameter of the coaxial opening **20** in the cylinder head **19** so as to provide an annular opening **43** between the outer wall of the rod **37** and the wall defining the opening **20** of the cylinder head. The annular opening is sized to permit substantially free flow of hydraulic fluid between an invagiating tube or flexible resilient fluid receiving member **44**.

The piston head **38** is preferably formed from a metal such as steel and comprises a disc-like body having a planar forward face **46** and a planar rearward face **47**. The planar rearward face **47** merges into a conical feed surface **48**, which terminates in a rim **49** and defines the perimeter of an orifice **51** formed coaxially in the piston head. The piston head **38** is formed on its forward face **46** with a recess **52** which receives the terminal end of the piston rod **37** and the latter is fixed to the piston head **38** by way of a weld.

For guiding the surface fluid displacement means for relative telescoping movement within the cylinder **11** and for forming a fluid seal between the inner wall of the cylinder **11** and the piston head **38**, the piston head **38** is provide with an elevated guiding surface means **53**. The bearing surface means is preferably formed from a material having a high compressive strength, good surface abrasive resistance characteristic and which does not have an affinity for the material from which the cylinder is formed so as to be capable of withstanding the high stresses caused in part by the high unit pressures and high temperatures associated with the operation of the device without encountering fatigue such as galling of the cylinder walls.

One material found to be particularly suitable for use as a guiding surface with the long travel cushioning device constructed in accordance with the present invention is a laminated phenolic resin, as for example having an NEMA (National Electrical Manufacturers Association) designation of 9 Coarse, Grade C.

The raised guiding surface means **53** formed of laminated phenolic resin is constructed as a split expandable ring which is seated within a groove **54** formed on the periphery of the piston head **38**. The guiding ring **54** is constructed so that it is snugly received within the groove **54** and expands and contacts the inner wall surface of the cylinder, thereby to form an efficient seal while at the same time providing a guiding surface which distributes the bearing stresses associated with the reciprocable movement of the piston head **38** within the bore **12** without resulting in a rupturing of the inner wall surface. It is to be particularly observed that the piston head is formed of reduced diameter and that the edges are formed with a distinct radius so as to substantially preclude metal-to-metal contact between the piston head **38** and the tube **16**.

The closure plate **39** is preferably formed from a mild steel and includes a hub **56** and a flange **56***a* against which an end of the resilient return spring means abuts. The hub is of substantially the same diameter as the tube **16** and as shown in FIG. 2, the end of the latter abuts the hub **56** in the fully contracted position. The closure plate **39** is fastened to the piston rod **37** by way of a bolt threaded into a plug which is secured as by welding into the bore adjacent the closure end thereof.

For metering the rate of flow from a high-pressure chamber **57** on one side of the piston **38** and through the orifice **51** of the piston head **38** the piston bore **41** and the ports **42** of the tubular piston rod to a low-pressure chamber **58** on the opposite side of the piston, there is provided the metering pin. The metering pin **14**, as shown, comprises essentially a rod of constant circular cross-sectional area along its length and which is provided with a plurality of flutes **60**, of which only one is shown, gradually tapering toward the rearward end thereof. The pin **14** is fixed at its head **59** as by threading into the cylinder head **17** of the cylinder **11**. Upon relative movement between the cylinder **11** and the fluid displacement means **13** during the application of a shock to the unit, the piston head **38** is positioned relative to the metering pin **14** so that the flow through the orifice **51** and the flutes **60** at any given distance of travel imparts a constant-force travel characteristic to the cushioning device. To this end, the flutes **60** are designed to conform substantially with the relationship

$$A_x = A_0\sqrt{1-\frac{x}{d}}$$

wherein A_x is the orifice area of any position x, over the total nominal stroke d (length of surface in which the flutes are formed) and A_0 is the initial orifice area defined by the orifice and the flutes at the beginning of the stroke under conditions where a completely rigid body is being cushioned from impact. For more complete description reference is made to the aforementioned U.S. patent applications Serial Nos. 782,786, now Patent Number 3,035,827, issued May 22, 1962, and 856,963, now Patent Number 3,003,436, issued October 10, 1961.

Fixed on and located forwardly of the ports **42** of the piston rod **37** is a stop ring **61** which, as shown in the phantom line position of FIG. 1, engages the cylinder head **19** so as to limit the travel of the fluid displacement means **13** to its fully extended position. This provides a minimum load pressure volume in the chamber **58** for receiving the fluid from the chamber **57** via the orifice **51** and bore **41** of the piston rod **37**.

For further extending the low pressure volume, there is provided the invaginating tube **44** which, as above described, has one end thereof fixed to the hub **21** of the cylinder head **19** as by hose clamps and the infolded end fixed to the piston rod **37** for movement therewith also by a hose clamp. The invaginating tube **44** is formed of a fluid impervious flexible material which is capable of resisting corrosive effects of the hydraulic liquid employed in the unit and advantageously may be a neoprene-buna

type of rubber having special additives for low temperature flexibility.

As shown, the resilient means 15 includes three helical compression springs 15*a*, 15*b* and 15*c* arranged in tandem and are employed for the purpose of extending the device to its fully extended position. The compression springs may be formed of a heat treated spring steel. If desired, the resilient spring means 15 may be in the form of either single or dual springs.

Located in the head 59 of the metering pin 14 is a charging check valve device 62 for charging hydraulic fluid into the unit. The head 59 is formed with an inner axial recess 63 which communicates with an enlarged recess 64 provided adjacent the terminal end thereof. Threadably secured with the inner recess is a plug 65 provided with an open-ended bore 66 which communicates at one end with an axial passage 67 and at its other end with the outer recess 64. The passage 67 is in constant communication with a diametrical passageway 68 formed in the body portion of the metering pin and located so as to communicate with the bore 12 of the cylinder when the metering pin 14 is assembled in the cylinder head 17.

Disposed within the recess is the check valve device 62 including a ball 71 biased by way of a compression spring 72 into seating engagement over the plug bore 66. For precluding leakage through the check valve structure, the enlarged recessed end of the metering pin head has screw-threaded therein a sealing plug 73 which is preferably in the form of an Allen-type pipe plug.

Operation

Assuming the device is assembled and devoid of hydraulic fluid and in its fully extended position, as shown by the phantom lines of FIG. 1 and the plug 73 is removed from the metering pin head 59, a hydraulic fluid, such as a noncorrosive, high-viscosity oil which retains its viscosity over a relatively wide range of temperatures, is introduced in the bore 66 of the plug 65 whereupon the flow of hydraulic fluid unseats the ball 71 to supply hydraulic fluid into the high-pressure chamber 57 via the recess 63, passage 67, and diametrical passageway 68 of the bore 12. At the same time, hydraulic fluid flows through the orifice 51 in the piston head 38, the flutes 60 of the metering pin 14, the piston bore 41 and ports 42 to the low-pressure chamber 58 and via the annular passageway 43 into the invaginating tube 44. The device is charged so that the pressure exerted by the fluid is maintained at a minimum, for example, about 2 p.s.i.

Assuming further that the cushioning device is employed in a railway car having a superstructure mounted for movement relative to the underframe wherein the device 10 is mounted in a pocket-like structure arranged to isolate shock imparted to the underframe from the superstructure, during normal transit and in the absence of buff or draft forces, the cushioning device 10 is in the fully extended position shown in FIG. 1 with the stop-ring 61 contacting the cylinder head 19. Upon the application of a shock in either buff or draft to the cushioned underframe, the tubular cylinder and the piston 26 and cylinder start movement toward each other. As the cushioning device contracts under the force being cushioned, the metering pin 14 displaces hydraulic fluid contained within the bore 41 of the piston rod 37 and the high-pressure chamber 57 on one side of the piston head 38 causing a hydraulic fluid flow through the orifice 51 into which the metering pin 14 extends. The metering pin as heretofore described is formed with the flutes 60 which are designed to provide a constant force-travel characteristic as the hydraulic cushion contracts under the shock force imposed upon the latter, i. e., the flutes 60 of the metering pin 14 are cooperative with the orifice 51 in the piston head 38 so that the flow of hydraulic fluid therethrough for every unit of travel of the piston head 38 relative to the cylinder 11 imparts a substantially constant cushioning effect to the cushioning device.

The hydraulic flow initiated by the relative movement of the piston head 38 and the cylinder 11 flows from the high-pressure chamber 58 through the orifice 51 and into the bore 41 of the piston rod 37 and thence radially outward through the ports 42 into the low-pressure chamber 58 of the bore 12. The hydraulic fluid flow through the ports 42 occurs at a relatively high velocity so that a turbulence is created as the displaced fluid enters the low-pressure chamber 58. This turbulence is caused at least in part by the radially directed flow of hydraulic fluid impinging directly against the inner wall of the tube so that a major portion of the kinetic energy of the hydraulic fluid is dissipated in the form of heat. In this connection, it is to be noted that the stop-ring 61 contacting the cylinder head is effective to limit the volume of the low-pressure chamber 58 and in this manner provides a chamber into which the hydraulic fluid displaced by the piston may freely enter as described above and thereby dissipate the kinetic energy in the form of heat under minimum shock conditions.

Upon further contraction of the cushioning device, the high-pressure chamber 57 continues to reduce in volume because of the advancement of the piston head 38 toward the cylinder head 17. The hydraulic fluid passing through the orifice 51 fills the low-pressure chamber 58, while at the same time a volume of hydraulic liquid equivalent to that displaced by the total entry into the fluid chamber of the piston rod passes through the annular opening 43 of the cylinder head and into the pocket defined by the invaginating boot 44, which inflates or expands and assumes substantially the position shown in the full line position of FIG. 1. The relationship of the diameter of the piston rod 37 and the opening 20 in the cylinder head 19 is such as to provide a relatively large volume annular opening resulting in a low-pressure hydraulic liquid flow from the low-pressure chamber into the invaginating boot.

After the shock has been fully dissipated, the compression springs 15*a*, 15*b* and 15*c* acting in tandem are operative to return the hydraulic cushion components to the initial extended position. During this movement, under the action of the compression springs, the oil flow previously described is reversed and the invaginating tubular member deflates and returns to the position shown. thereby insuring that the hydraulic liquid displaced by the piston is restored to its normal operative position.

What is claimed is:

1. A hydraulic cushioning device comprising a hydraulic fluid containing cylinder including an open-ended tube, a first cylinder head closing one end of said tube, a second cylinder head located between the open and closed ends of said tube and including a peripheral keyway, a plurality of peripherally spaced openings extending through the wall of said tube, key means disposed in said keyway and accessible through said openings for positioning said key means to fix said second cylinder head against axial movement within said tube, fluid displacement means movable through said second cylinder head and including a piston head located between said cylinder heads and defining a high-pressure chamber adjacent said first cylinder head and a low-pressure chamber adjacent said second cylinder head, a flexible fluid receptacle connected to said fluid displacement means and said second cylinder head adjacent the open end of said tube and in constant communication with said low-pressure chamber, and orifice means providing communication between said high and low-pressure chambers.

2. The invention as defined in claim 1 in which said tube is also provided with a keyway, said key means comprising a snap ring seatable in a contracted position wholly within the confines of said peripheral cylinder head keyway and seatable in an expanded position within both of said keyways to key said second cylinder head to said tube, and means in said openings for selectively expanding and contracting said ring.

3. The invention as defined in claim 1 in which said

key means comprises a plurality of key members of which each is receivable within a respective one of said openings and fixedly positionable within said peripheral cylinder head keyway.

4. The invention as defined in claim 3 in which each of said openings is in the form of a rectangular slot, and each of said key members is formed to be snugly received therein and includes a pair of spaced ear-like projections receivable within said peripheral key way and wedgeable between the inner wall of said tube and the bottom wall of said keyway.

5. In a hydraulic cushioning device including a tube having a first cylinder head fixed to one end and a second cylinder head between the ends of said tube and a fluid displacement means telescopingly arranged relative to said cylinder and operative to displace fluid within said tube to dissipate kinetic energy of a force applied to said device in the form of heat, the improvement comprising a peripheral keyway formed in said second cylinder head, keyway means in said tube having openings through the wall alignable with said keyway, and key means seated in said peripheral keyway and accessible through said openings to position said key means in a keying position.

6. The invention as defined in claim 5 in which said key means comprises a snap ring seatable in a contracted position wholly within the confines of said peripheral keyway and seatable in an expanded position within both said peripheral keyway and keyway means to key said second cylinder head to said tube, and means in said openings for selectively expanding and contracting said ring.

7. The invention as defined in claim 5 in which said key means comprises a plurality of key members of which each is receivable within a respective one of said openings and fixedly positionable within said peripheral keyway.

8. The invention as defined in claim 7 in which each of said openings is in the form of a rectangular slot and each of said key members is formed to be snugly received therein and includes a pair of spaced ear-like projections receivable within said peripheral keyway and wedgeable between the inner wall of said tube and the bottom wall of said keyway.

9. In a hydraulic cushioning device wherein a cylinder is provided with an intermediate cylinder head internally thereof through which piston means is reciprocable within said cylinder, the provision of intermediate cylinder head keying means for cylinder head position fixing, said keying means comprising outer peripheral keyway means forming a part of said cylinder head, key means in said cylinder and projecting into said keyway means to position said cylinder head, and seating means for said key means carried by said cylinder and accessible externally thereof for controlled positioning of said key means relative to said cylinder head.

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