United States Patent

[11] 3,554,528

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[45] Patented **Jan. 12, 1971**

[54] **ENERGY DISSIPATING HYDRAULIC SYSTEMS**
29 Claims, 24 Drawing Figs.

[52] **U.S. Cl.** **267/126**
[51] **Int. Cl.** **F16f 5/00**
[50] **Field of Search** 267/114V, 116V, 119V, 130V

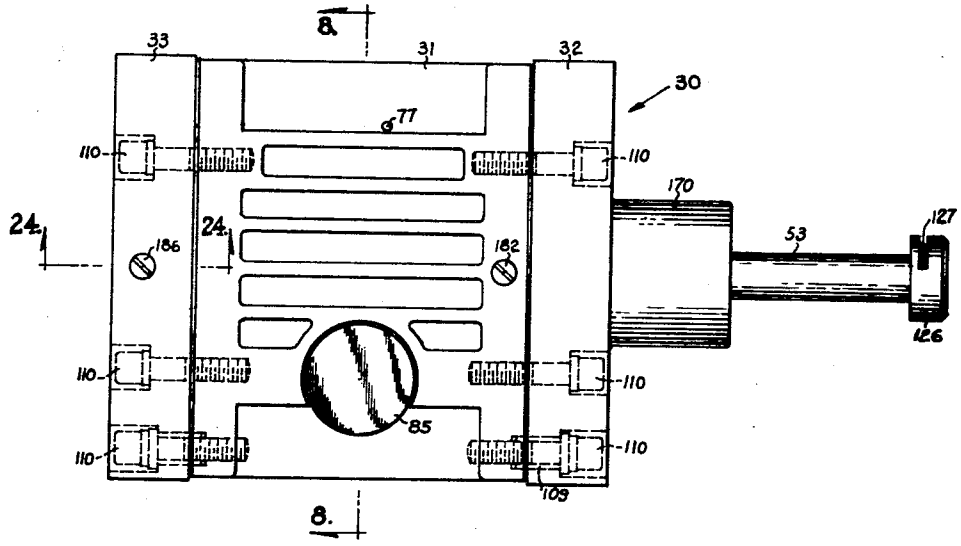
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Primary Examiner—James B. Marbert
Attorney—William L. Fisher

ABSTRACT: Improvements in energy dissipating hydraulic systems are disclosed for dissipating the energy of impacting forces comprising an industrial-type hydraulic shock absorber having an hydraulic ram chamber and an hydraulic ram operative therein which has a single energy dissipating power stroke in respect to an impacting force acting in one direction thereon. A self-contained hydraulic reservoir, a piston therein and yieldable means operative upon said piston are provided. Means interconnecting the ram chamber and the reservoir are provided so that a transfer of hydraulic liquid occurs in opposition to said yieldable means from said ram chamber to said reservoir under relatively free flow conditions for a first part of said power stroke and under flow restriction conditions for the remainder thereof. Said ram chamber provided with axially spaced orifices all but the last of which are closed off progressively by said hydraulic ram in its movement to its retracted position in said ram chamber during said power stroke. The first of said orifices being free flow orifices through which hydraulic liquid flows from said ram chamber to said reservoir under free flow conditions for a first part of said power stroke and the remainder of said orifices being flow restriction orifices through which hydraulic liquid flows from said ram chamber to said reservoir under flow restriction conditions for the remainder of said power stroke. Said hydraulic ram being fully retracted without closing off the last of said flow restriction orifices. At the end of the power stroke the reservoir piston effects a return of hydraulic liquid from the reservoir to the ram chamber to return the ram in the opposite direction in a single return stroke thereof. Said interconnecting means includes unidirectional valve means closed during said power stroke and open to the ram chamber during said return stroke.



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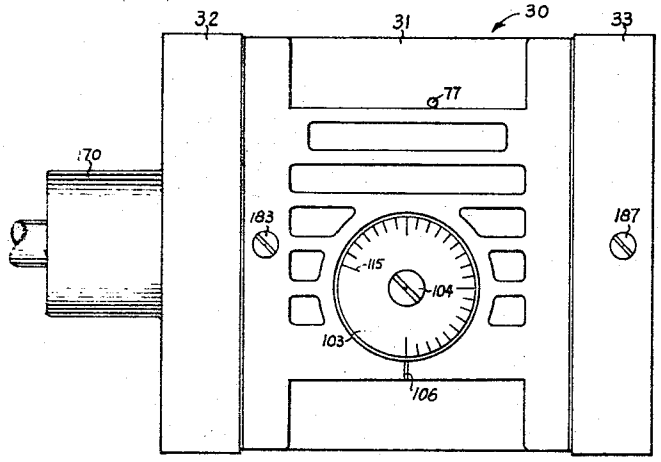


Fig_3

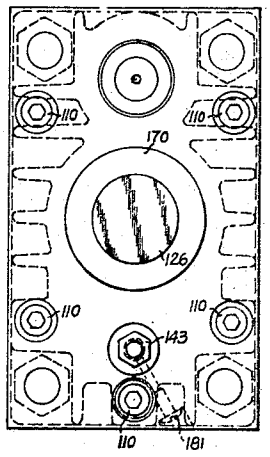


Fig_4

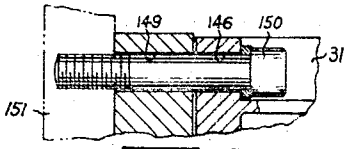


Fig_5

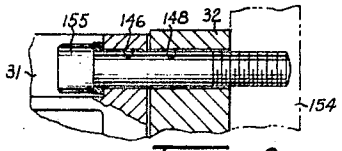


Fig_6

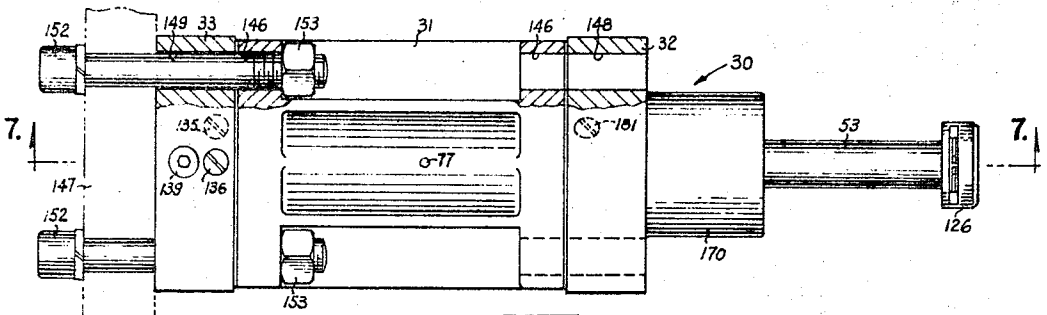


Fig_2

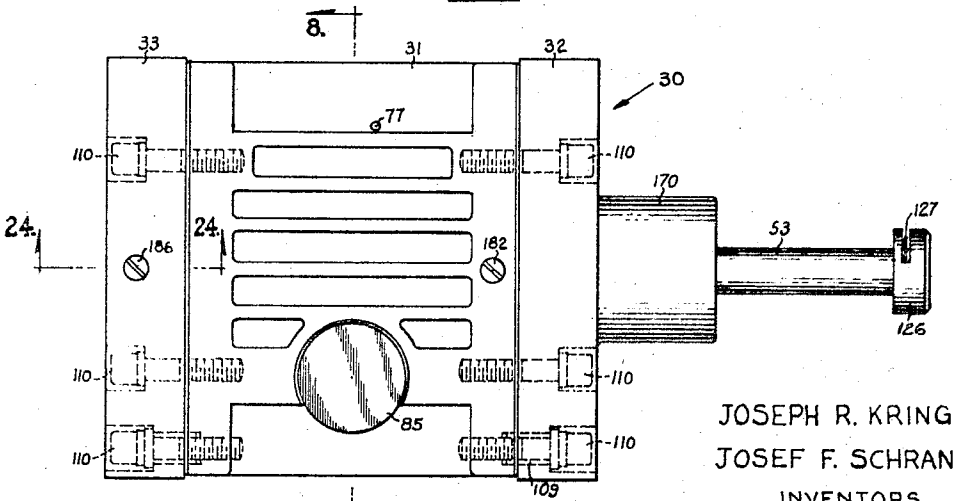


Fig_1

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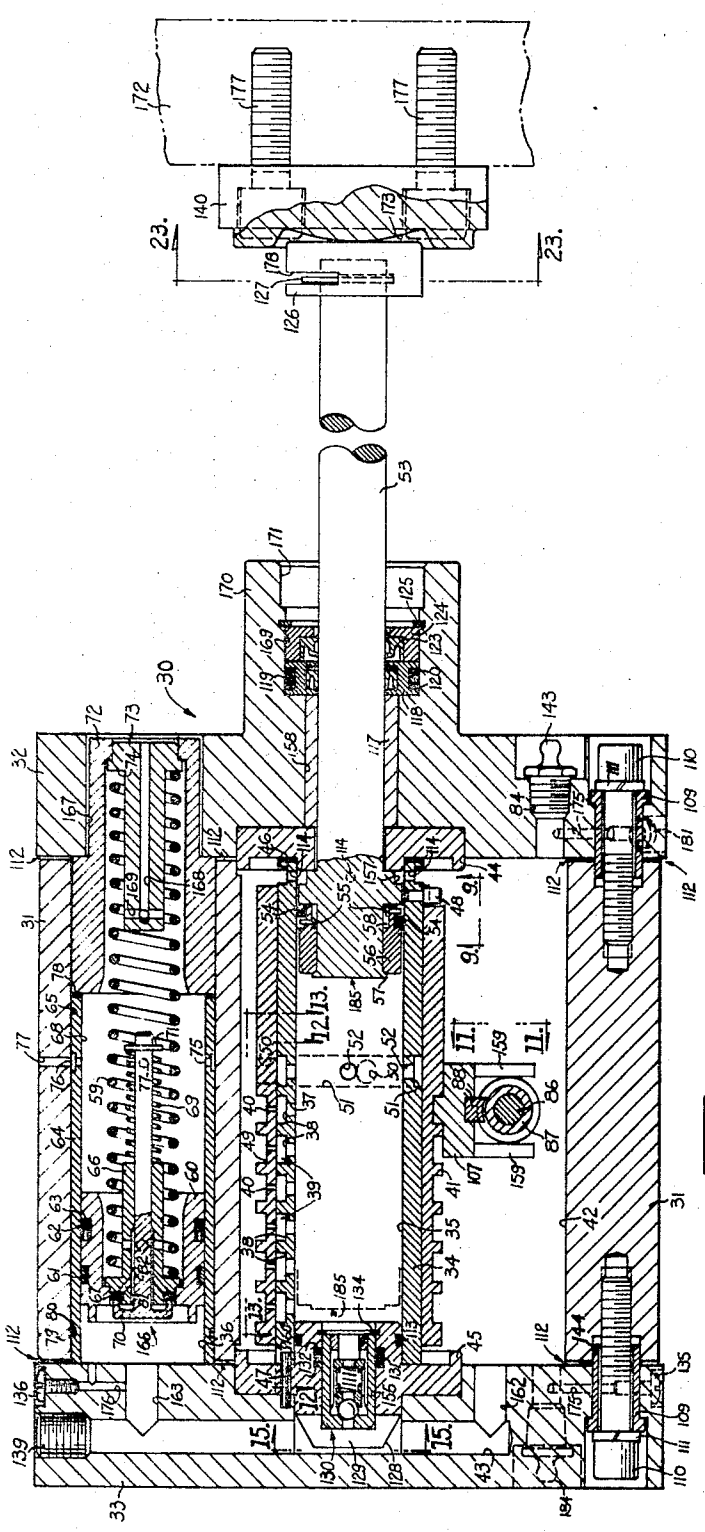


Fig - 7

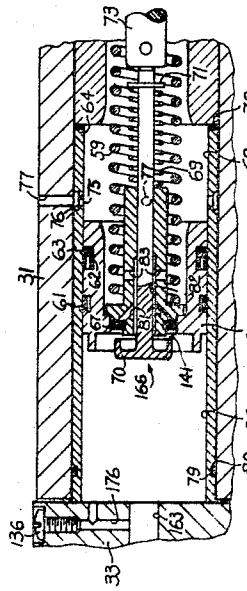


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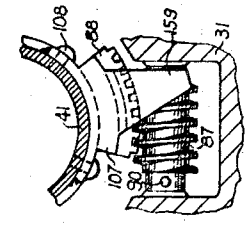


Fig - 11

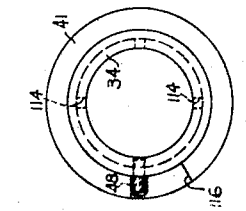


Fig - 10

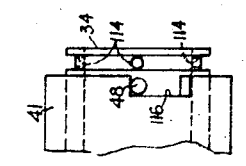


Fig - 9

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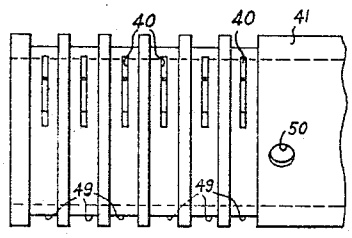


Fig - 13

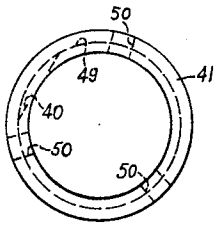


Fig - 14

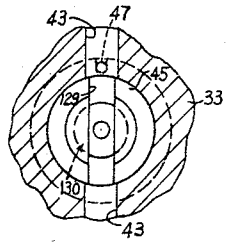


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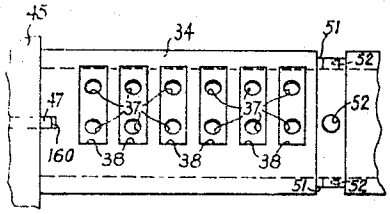


Fig - 12

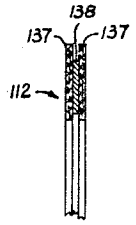


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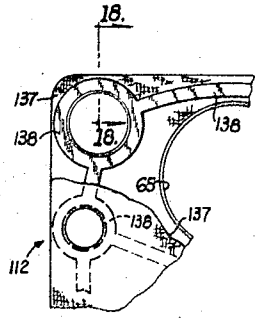


Fig - 17

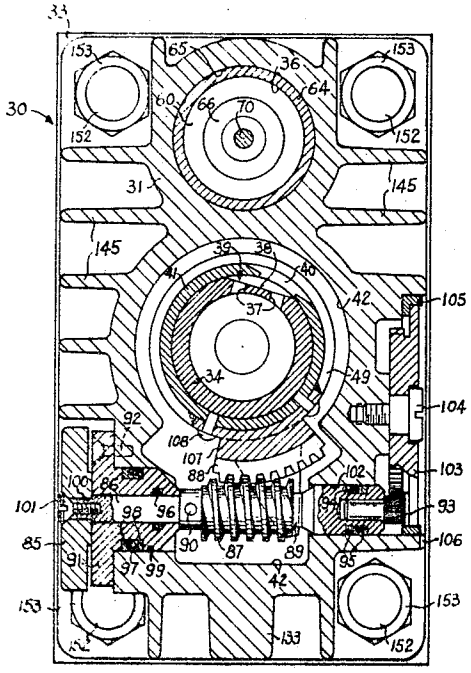


Fig - 8

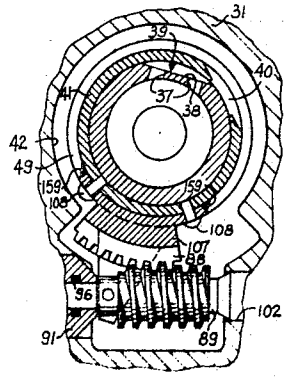


Fig - 16

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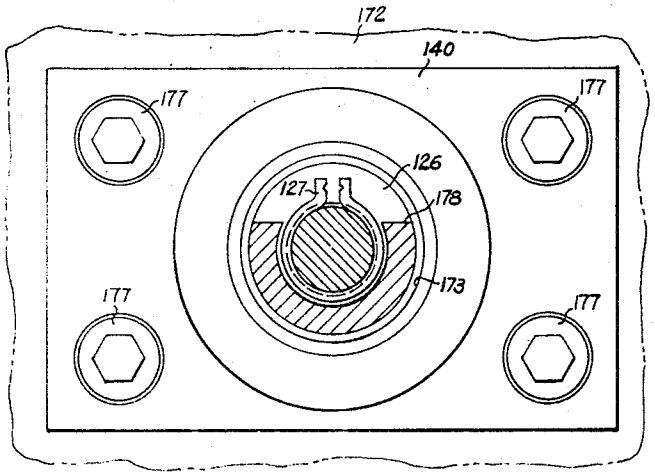


Fig - 23

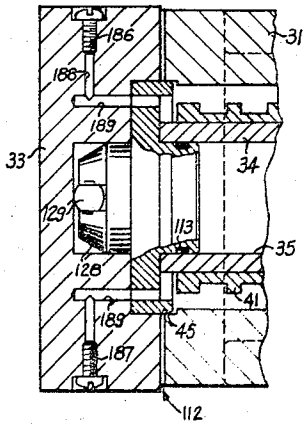


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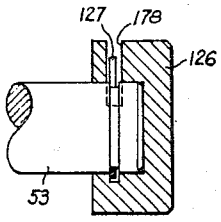


Fig - 22

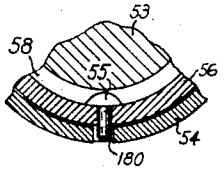


Fig - 21

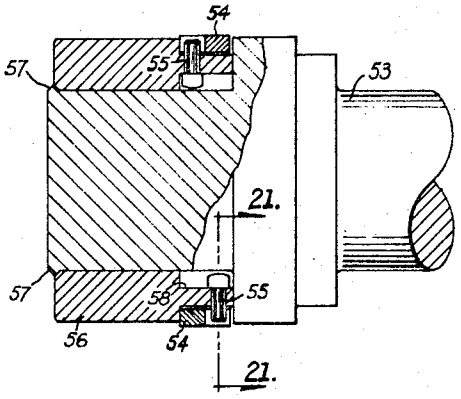


Fig - 20

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ENERGY DISSIPATING HYDRAULIC SYSTEMS

Our invention relates to energy dissipating hydraulic systems and more particularly to industrial-type hydraulic shock absorbers.

The principal object of our invention is the provision of an industrial-type hydraulic shock absorber which has such improved features of construction that it is self-contained, self-cooling, self-indicating as to fullness when being filled, truly adjustable in respect to its cushioning effect and rugged in respect to its size and weight so as to be capable of withstanding impacting forces of high order and particularly if such impacting forces are of a repetitive nature.

The foregoing object of our invention and its advantages will become apparent during the course of the following description, taken in conjunction with the accompanying drawings, in which:

FIGS. 1, 3 and 4 are, respectively, opposite side and front elevational views of an industrial-type hydraulic shock absorber embodying our invention;

FIG. 2 is a plan view of said embodiment with parts in section showing the same rear mounted;

FIGS. 5 and 6 are fragmentary views showing alternate mounts for said embodiment;

FIG. 7 is a longitudinal sectional view of said embodiment taken on the line 7–7 of FIG. 2;

FIG. 8 is a transverse sectional view of said embodiment taken on the line 8–8 of FIG. 1; and

FIGS. 9—24 are fragmentary views of parts of said embodiment.

Referring to the drawings in greater detail, 30 designates said embodiment generally and 31 the center section thereof which is fastened at its opposite ends to front and rear end plates 32 and 33, respectively, via fasteners 110. Spring washers 111 are used in conjunction with said fasteners 110 to insure their security. Steel liners 209 surround the fasteners 110 and extend into counterbores 144 formed in the center section 31 for alignment of the end plates 32 and 33 with the center section 31. Gaskets 112 which comprise layers 137 of an asbestos material having a steel band 138 sandwiched therebetween are used to form liquid tight seals between the center section 31 and the end plates 32 and 33. The steel band 138 embraces each aligned aperture between the center section 31 and the end plates 32 and 33 and embeds itself into the asbestos layers 137 which in turn force themselves into irregularities in the mating machined surfaces creating a tight sealing condition. The center section 31 is an investment casting which is provided with fins 145 for better cooling the hydraulic liquid in the embodiment 30 via ambient air. The center section 31 has mounting apertures 146 through its flange portions on its opposite ends which are aligned with apertures 148 and 149 in the end plates 32 and 33, respectively, by which the embodiment 30 may be rear or front mounted as desired. FIGS. 2 and 8 show the embodiment 30 rear mounted on suitable structure 147 via socket head fasteners 152 which are engaged by locknuts 153 held against rotation by the walls of section 31. FIG. 5 shows the embodiment 30 rear mounted on structure 151 by fasteners 150. FIG. 6 shows the embodiment 30 front mounted on structure 154 by fasteners 155.

An inner pressure cylinder 34 defining a pressure chamber 35 is provided centrally of the center section 31 and held therein by retainer inserts 44 and 45 which are disposed in end plates 32 and 33, respectively. A portion of the insert 45 projects into an end of the cylinder 34 and is liquid-tight sealed in respect thereto by a bronze piston ring 113. A spring washer 46 of the three-wave type is provided between the cylinder 34 and the insert 44 to force the cylinder 34 against the insert 45 for positioning and to eliminate close tolerance machining. The cylinder 34 rotatably supports an outer cylinder 41 the purpose of which will appear hereinafter. The cylinder 34 slidably carries an hydraulic ram, generally designated 185, comprising a hard aluminum bronze sleeve 56 which is staked, as at 57, over the inner end of a piston rod 53 and liquid-tight sealed in respect to the cylinder 34 by a pair of piston rings 54

which are held in predetermined circumferential relationship with each other (i.e. so that the space at the ends of each, as at 180 in FIG. 21, are spaced apart from each other diametrically) by rivets 55, the heads of which are disposed in an annular groove 58. The inside diameter of the cylinder 34 is honed. Opposite its end in which the piston rod 53 operates the cylinder 34 is closed against flow of hydraulic liquid therefrom but not thereinto by a check valve 130 disposed in a bore 156 in the insert 45 and held therein by a bowed retainer ring 134. The check valve 130 is liquid-tight sealed in the bore 156 by an O-ring 132 and backup rings 132 therefor. The cylinder 34 is provided with a groove 51 and four equally circumferentially spaced radial apertures 52 which (together with three such spaced radial apertures 50 in the cylinder 41) provide free travel of the piston 185 for an initial portion (about one-third) of its travel. Behind its piston rings 54 the piston 185 is relieved, as at 157, for accommodating displaced hydraulic liquid via equally circumferentially spaced radial apertures 114 in the cylinder 34. The cylinder 34 is also provided with six longitudinally spaced flats 38 machined in its outer surface which define a like number of cavities between itself and the cylinder 41. In each such flat 38 are formed a pair of spaced radial apertures 37. The flats 38 and apertures 37 together with other cooperating structure including that on the cylinder 47 affect travel of the piston 185 for the remaining portion (about two-thirds) of its travel. At the end of such travel the piston 185 assumes the extreme retracted position shown for it in dotted outline in FIG. 7. Such cooperating structure includes honed finishes on the mating surfaces of the cylinder 34 (its O.D.) and of the cylinder 41 (its I.D.) and six longitudinally spaced through-slots 40 formed through the wall of the cylinder 41 in annular grooves 49 therein. The slots 40 constitute metering orifices and are longitudinally centrally aligned in respect to the cavities defined by the flats 38 and form therewith variable area metering orifices 39 which are adjustable in area by virtue of the rotatable disposition of the cylinder 41. The maximum area position of the metering orifices 39 occurs when the slots 40 are fully open in respect to the cavities defined by the flats 38 as shown in FIG. 8. The minimum area position of such metering orifices 39 occurs when the slots 40 are maximumly closed in respect t o the cavities defined by the flats 38. FIG. 16 shows such minimum area position from which it can be noted that such variable area metering orifices 39 are never fully closed to protect against breakage of parts of the embodiment 30 as well as of the impacting structure intended to be decelerated. Flow of hydraulic liquid out of the variable area metering orifices 39 is into an intermediate relief chamber 42 formed in the center section 31 concentrically about the cylinder 34 and also therebeneath as shown in FIGS. 7 and 8. Rotation of the cylinder 41 is accomplished by a transversely disposed driftless gear train including a worm 87 fast (via pin 90 and shoulder 89) on a shaft 86 rotatably supported in a bore 102 in the center section 21 and in a retainer insert 91. The bore 102 is liquid-tight sealed in respect to the outside by an O-ring 94 and a pair of backup rings 95 on opposite sides thereof. The insert 91 in turn is held fast in a bore 99 in the center section 37 via fasteners 92 which bore 99 is similarly sealed by an O-ring 97 and a pair of backup rings 98. The portion of the shaft 86 carried in the insert 91 is liquid-tight sealed in respect to the outside via an O-ring 96. A knurled knob 85 is carried fast on an end of the shaft 86 (such end being square in cross section over the portion 100 thereof and having a tapped aperture for engaging the flat head screw 101) and a pinion gear 93 is carried fast on its opposite end. The pinion gear 93 meshes with a gear 103 which is rotatably supported on the center section 21 via a shoulder screw 104. The gears 93 and 103 are sealed against entrance of foreign matter by a seal 105 which is preferably of oil resistant material such as nitrile rubber. The gear 103 is graduated on its outside face (FIG. 1) and a reference mark 106 is provided on the outside wall of the center section 31 to serve as a reference in respect to the rotated position of the gear 103. Zero and 115 designate,

respectively, the maximum and minimum restriction positions for the variable metering orifice **39**. The worm **87** meshes with a gear segment **88** which is carried fast on a member **107** fastened to the cylinder **41** via drive studs **108** and welds as shown. The member **107** has a forked portion **259** which projects outwardly of the gear segment **88** and embraces the worm **87** to position the outer cylinder **41** axially in respect to the pressure cylinder **34** during assembly. The forked portion **159** centers the gear segment **88** in respect to the worm **87**. A full 360° revolution of the knob **85** rotates the cylinder **41** 6 circular degrees and the graduated face gear **103** 50 circular degrees. Maximum rotation of the cylinder **41** is 30 circular degrees corresponding to five full revolutions of the knob **85** and 250 circular degrees of revolution of the gear **203** (corresponding to movement of the gear between its zero setting and its maximum setting as at 115). Limitation of rotation of the cylinder **41** to its maximum of 30 circular degrees is accomplished by an opensided slot **126** in an end of the cylinder **41** and a pin **48** projecting from the cylinder **34** so as to operate in the slot **116**. For this reason the cylinder **34** must be circumferentially located during assembly in respect to the cylinder **41** which is accomplished by a locating pin **47** which is disposed in a slot **160** in the cylinder **34** and projects through the insert **45** into the end plate **33**.

Flow of hydraulic liquid from the intermediate chamber **42** occurs into a reservoir **36** via passageways **162**, **43** and **163** formed in the end plate **33**. A portion of the insert **45** projects into the passageway **43** and is provided with a throughout **229** for passing hydraulic liquid through the interruption in the passageway **43** occasioned by the presence of such projecting portion of the insert **45**. The open end of the passageway **43** is closed by a plug **139**. The reservoir **36** is formed by a honed liner **64** disposed in a bore **65** in the center section **31** above the chamber **42** and a piston, generally designated **166**, slidably carried in the liner **64**. The liner **64** is held in place in the bore **65** by an annular retainer insert **72** and between the two of them is a spring washer **78** of the three-wave type employed to position the liner **64** against end plate **33** and to eliminate close tolerance machining. An O-ring **79** and backup ring **80** therefor form a liquid-tight seal for the liner **64** in respect to the bore **65**. The insert **72** extends through the end plate **32** via a bore **167** therein concentric with the bore **65** and in turn holds another insert **73** which has intersecting longitudinal **168** and transverse **169** passageways therein for purposes which will appear. The insert **73** has an annular shoulder **74** against which one end of a compression spring **59** operates, the other end of which operates against another insert **66** which is a part of the piston **166**. The latter is made in separable component assemblies one of which comprises an outer piston sleeve **60** which is liquid-tight sealed in respect to the liner **64** by a U-cup sealed **62** and backup ring **63** therefor. An advance located piston ring **61** takes up shock and protects the U-cup seal **62** from high shock pressures exerted against the piston **166**. It also compensates for heat and pressure expansions of the liner **64**. The other component assembly of the piston **166** comprises a stainless steel valve stem **70** held against the insert **66** by a compression spring **69** which operates against a retainer ring **71** on an end of the valve stem **70** and against an end of the insert **66**. The opposite ends of the insert **66** and the stem **70** are liquid-tight sealed in respect to each other and in respect to the piston sleeve **60** by means **67** in the form of a square-cut seal ring. The chamber in the liner **64** behind the piston **166** is designated **68** and is vented to atmosphere exterior of the embodiment **30** via four equally circumferentially space radial apertures **75** and an annular groove **76** in the liner **64** and by three 90° circumferentially spaced radial apertures **77** in the center section **31**. The passageways **168** and **169** in the insert **73** also vent the chamber **68**.

The piston rod **53** is chrome plated and operates in a bronze bearing **117** press-fitted into a bore **158** in a protrusion **170** formed on the front of the end plate **32** and beyond the bearing **117** is liquid-tight sealed in respect to displaced hydraulic liquid by mechanism disposed in a bore **169** in said protrusion **170** which includes a U-type packing seal **121** about the piston rod **53** and backup ring **122** therefor and an O-ring **119** about the bore **169** and backup rings **120** therefor which are held in place by a retainer insert **118**. Said mechanism also includes a wiper **123** for the piston rod which is held in place by a retainer insert **124**. A bowed retainer ring **125** locks said mechanism in place in the bore **169**. An enlarged bore **171** is formed in the protrusion **170** outwardly of the bore **169** to receive a cap **126** carried on the free end of the piston rod **53** and made fast thereto by a prong ring **127**. The end cap **126** is slotted, as at **178**, to provide access to the prong ring **127** to squeeze the same for purposes of removing or replacing the end cap on said free end of the piston rod **53**. For cooperation with the end cap **126** an impact plate **140** is provided for affixation by suitable fasteners **177** to moveable structure, as at **172**, which is intended to impact against the piston rod **53**. The engaging face of the impact plate **140** is arcuately contoured, as at **173**, to minimize side thrust on the piston rod **53** and its bearing **117**.

The embodiment **30** is filled with hydraulic oil via an oil fitting **143** threadably engaged in an aperture **84** in the end plate **32**. (If the embodiment **30** is front mounted the oil fitting **184** in the end plate **33** may be used.) During filling the ram **185** preferably is forcefully held in its extreme retracted position. Hydraulic oil is forced into the embodiment **30** with the ram **185** so held until the intermediate relief chamber **42** and the reservoir **36** are completely filled as well as the space behind the ram **185** which occurrence is signaled by flow of hydraulic oil out of the chamber **68** via the aperture **77** and/or the passageways **168**. During filling of the embodiment **30** flow of hydraulic oil occurs from the reservoir **36** into the chamber **68** as shown in FIG. **19** by the unseating of the valve stem **70** from the square-cut seal **67** which occurs from continued travel of the piston sleeve **60** after the stem **70** bottoms against the insert **73**. The insert **66** has an axial bore **82** and diametrically disposed radial apertures **83** to provide for such flow of hydraulic oil during filling of the embodiment **30**. A relief passageway **81** behind the seal ring **67** communicates with the bore **72** to insure that the seal **67** will remain seated in the event of sudden opening of the valve stem **70**. Filling of the embodiment **30** is terminated as soon as hydraulic oil is noted to flow out of the apertures **77** and/or the passageway **168**. The system is vented by loosening self-sealing vent screws **135** and **136**, respectively, in passageways **275** (in end plate **33**) and **176** (in end plate **33**). Further vent screws **181** (in end plate **32**) and **182** and **183** (in opposite sides of center section **31**) and **186** and **187** (in opposite sides of the end plate **33**) are provided to accommodate the multiple positions in which the embodiment **30** may be disposed in use. These multiplely located vent apertures permit proper bleeding of the embodiment **30** at any angle at which it may be mounted. After filling, the reservoir piston **166** moves to the left to the position shown for it in FIG. **7** and in doing so moves the ram **185** to its extreme extended position shown for it in FIG. **7**.

In operation of the embodiment **30** the impacting force which is sought to be absorbed in transmitted to the piston rod **53** preferably via the impact plate **140** and such force causes the piston **185** to move in its energy-dissipating power stroke. The initial portion of the travel of the piston **185** is under substantially free flow conditions as hydraulic oil is forced out of the pressure chamber **35** without restriction via the apertures **52** and the annular groove **51** in the cylinder **34** and the apertures **50** in the cylinder **41**. The remaining portion of the travel of the piston **185** (after the same closes off the apertures **52**) is restricted from the flow restriction presented by the variable area metering orifices **39** to the flow of hydraulic liquid from the pressure chamber **35** into the intermediate relief chamber **42**. Such flow of hydraulic liquid into the chamber **42** displaces hydraulic liquid therein and in the reservoir **36** which causes the piston **166** to move against the urging of the spring **59**. Some hydraulic liquid displaced from the chamber **32** is forced behind the piston **185** via the apertures **114** in the

cylinder 34 and lubricates the piston rod 43 in its bearing 107. The stiffness with which the piston 185 absorbs the shock of the impacting force can be varied to suit the particular application by rotating the knob 75 to adjust the area opening presented by the variable area metering orifices 39. A user can tell to what degree of cushioning the embodiment 30 is set for simply from glancing at the setting on the graduated face of the gear 103. Upon removal of the impacting force from the piston 185 hydraulic liquid flows from the reservoir 36 under the force of the piston 166 into the pressure chamber 35 without restriction via the check valve 130 to return the piston 185 rapidly to its rest position shown in full lines in FIG. 7. The system is unaffected by hydraulic losses due to the hydraulic liquid stored in the reservoir 36 and the continual pressure maintained by the piston 166 on the hydraulic liquid in the chamber 42 and in the pressure chamber 35. The piston 166 continually maintains a nearly steady oil pressure in the system which increases the useful life of the seals.

It will thus be seen that there has been provided by our invention an industrial-type hydraulic shock absorber in which the object hereinabove set forth together with many other thoroughly practical advantages has been successfully achieved. While preferred embodiments of the invention have been shown and described it is to be understood that variations and changes may be resorted to without departing from the spirit of the invention as defined by the appended claims.

We claim:

1. Means in energy dissipating hydraulic systems for dissipating the energy of impacting forces comprising:

a. an hydraulic ram chamber and an hydraulic ram operative out of one end thereof, said ram having a single energy dissipating power stroke in respect to an impacting force acting in one direction thereon;

b. an hydraulic reservoir, a piston operative therein, and yieldable means operative upon said piston;

c. means interconnecting said ram chamber and said reservoir so that a transfer of hydraulic liquid occurs in opposition to said yieldable means from said ram chamber to said reservoir under relatively free flow conditions for a first part of said power stroke and under flow restriction conditions for the remainder thereof;

d. said ram chamber provided with axially spaced orifices all but the last of which are closed off progressively by said hydraulic ram in its movement to its retracted position in said ram chamber during said power stroke; the first of said orifices being free flow orifices through which hydraulic liquid flows from said ram chamber to said reservoir under free flow conditions for a first part of said power stroke and the remainder of said orifices being flow restriction orifices through which hydraulic liquid flows from said ram chamber to said reservoir under flow restriction conditions for the remainder of said power stroke; said hydraulic ram being fully retracted without closing off the last of said flow restriction orifices;

e. said reservoir piston operative at the end of said power stroke to effect return of hydraulic liquid from the reservoir to the ram chamber to return the ram in the opposite direction in a single rapid return stroke thereof; and

f. said interconnecting means including unidirectional valve means at the end of said ram chamber opposite that from which said ram operates which is closed during said power stroke and open to the ram chamber during said return stroke.

. 2. Means according to claim 1 further comprising means for varying the area of said flow restriction orifices comprising concentric cylinders which have communicating flow restriction orifices and means for rotating said cylinders relative to each other to vary the effective flow area of said flow restriction orifices to alter the cushioning effect of said power stroke in accordance with the magnitude of the impacting force.

3. Means according to claim 2 in which the outer cylinder is provided with axially spaced slits and means for rotating said outer cylinder relative to the inner cylinder to vary said effective flow area.

4. Means according to claim 1 further comprising housing means for the reservoir and said chamber having cooling fins on the exterior thereof for transfering heat from said hydraulic liquid to ambient air during both said power and return strokes for cooling purposes.

5. Means according to claim 1 in which the reservoir piston is provided with axially separable valve means permitting flow of hydraulic liquid through said piston during filling of said reservoir to prevent overfilling thereof.

6. An hydraulic shock absorber according to claim 1 having housing means with fins on its exterior for cooling hydraulic liquid therein via ambient air.

7. An hydraulic shock absorber according to claim 1 in which said ram includes a hard aluminum bronze piston sleeve and a pair of piston rings therefor and held thereon in diametrically opposed circumferential relationship to each other.

8. An hydraulic shock absorber according to claim 1 further comprising an end cap for the free end of said ram and resilient releasable holding means for said end cap.

9. An hydraulic shock absorber according to claim 8 further comprising an arcuately contoured impact plate for use in conjunction with said end cap for reducing side thrust on said ram.

10. An hydraulic shock absorber according to claim 1 in which the wall of said reservoir is provided by a honed liner and in which said yieldable means comprises compression spring means operating on the reservoir piston to maintain the hydraulic liquid in the reservoir under a yieldable pressure.

11. An hydraulic shock absorber according to claim 9 in which the reservoir piston is provided with liquid-tight seal means in respect to said liner and a piston ring in advance of said seal means to absorb surge hydraulic pressures on the reservoir piston.

12. An hydraulic shock absorber according to claim 3 in which said means for rotating said outer cylinder comprises a driftless gear train including a worm and a manually rotated knurled knob.

13. An hydraulic shock absorber according to claim 12 in which graduated readout means are provided on the gear train for determining the setting of said metering orifice.

14. An hydraulic shock absorber according to claim 13 in which said gear train includes a gear segment meshing with said worm and a bifurcated mechanism centering said gear segment in respect to said worm.

15. An hydraulic shock absorber according to claim 1 in which said reservoir piston comprises valve means including an axially moveable valve stem and liquid-tight seal means therefor and means to open said valve means when the reservoir piston reaches a predetermined position in its travel during filling of the shock absorber to prevent overfilling thereof.

16. An hydraulic shock absorber according to claim 3 in which said inner cylinder has a series of flats on its exterior circumferential surface and radial apertures through its wall intersection each such flat.

17. An hydraulic shock absorber according to claim 3 in which said flow restriction orifice on said outer cylinder comprises a series of annular grooves and a tangential flow restriction slot through its wall intersecting each such groove.

18. An hydraulic shock absorber according to claim 1 in which liquid-tight seal means are provided between said unidirectional valve means and said ram chamber comprising piston ring means operative against the wall of said ram chamber.

19. An hydraulic shock absorber according to claim 1 which is so constructed as to be operative in any position in which it may be mounted, and manually openable normally closed vent means at different locations on the body of said shock absorber so that the hydraulic liquid therein can be air-bled in every such mounted position of said shock absorber.

20. Process in energy dissipating hydraulic systems for dissipating the energy of impacting forces comprising:

a. applying pressure in a single energy dissipating power stroke to hydraulic liquid in a hydraulic ram chamber via an impacting force acting in one direction upon an

hydraulic ram operating out of one end of said ram chamber;

b. transferring hydraulic liquid from said ram chamber to hydraulic liquid in an hydraulic reservoir maintained under yieldable pressure;

c. said transferring of hydraulic liquid being accomplished by movement of an hydraulic ram to its retracted position in said ram chamber during said power stroke by said ram progressively closing off all but the last of axially spaced orifices in said ram chamber; the first of said orifices being free flow orifices through which hydraulic liquid flows from said ram chamber to said reservoir under free flow conditions for a first part of said power stroke and the remainder of said orifices being flow restriction orifices through which hydraulic liquid flows from said ram chamber to said reservoir under flow restriction conditions for the remainder of said power stroke; said hydraulic ram being fully retracted without closing off the last of said flow restriction orifices; and

d. at the end of said power stroke applying pressure to said hydraulic liquid in said ram chamber by effecting return of hydraulic liquid thereto from said reservoir under said yieldable pressure and under free flow conditions to produce a return force acting in the opposite direction in a single return stroke.

21. Process according to claim **20** in which said ram chamber and said reservoir are filled by transferring hydraulic liquid under pressure into said reservoir until it visibly flows out therefrom.

22. Process according to claim **20** in which a flow restricting orifice is moved relative to a cavity to alter the cushioning effect of said power stroke in accordance with the magnitude of the impacting force.

23. Process according to claim **22** in which said flow restricting orifice is rotated relative to said cavity between maximum and minimum area positions corresponding, respectively, to maximum and minimum flow of hydraulic liquid through said cavity and said flow restricting orifice.

24. Process according to claim **20** further comprising transfering heat from said hydraulic liquid to ambient air during both said power and return strokes for cooling purposes.

25. An industrial type hydraulic shock absorber having a center section and end plates bolted to said center section at opposite ends thereof, an hydraulic ram chamber defined by a cylinder fast in said center section between said end plates, an hydraulic ram operative in said ram chamber and out of one of said end plates, said ram having a single energy dissipating power stroke in respect to an impacting force acting in one direction thereon, an hydraulic reservoir defined by a chamber in said center section, a piston slidable in said reservoir and yieldable means operative upon said piston, means interconnecting said ram chamber and said reservoir so that a transfer of hydraulic liquid occurs in opposition to said yieldable means from said ram chamber to said reservoir under free flow conditions for a first part of said power stroke and under flow restriction conditions for the remainder thereof, said ram chamber provided with axially spaced orifices all but the last of which are closed off progressively by said hydraulic ram in its movement to its retracted position in said ram chamber during said power stroke. The first of said orifices being free flow orifices through which hydraulic liquid flows from said ram chamber to said reservoir under free flow conditions for a first part of said power stroke and the remainder of said orifices being flow restriction orifices through which hydraulic liquid flows from said ram chamber to said reservoir under flow restriction conditions for the remainder of said power stroke. Said hydraulic ram being fully retracted without closing off the last of said flow restriction orifices, said reservoir piston operative at the end of said power stroke to effect return of hydraulic liquid from the reservoir to the ram chamber to return the ram in the opposite direction in a single return stroke thereof, said interconnecting means including unidirectional valve means closed during said power stroke and open to the ram chamber during said return stroke.

26. An hydraulic shock absorber according to claim **25** in which said ram chamber is defined by a first cylinder fast in said center section between said end plates, and further comprising an intermediate relief chamber defined by a cavity in said center section and a second cylinder concentric about and supported for rotation on said first cylinder, flow restriction means in said second cylinder providing a variable area metering orifice for flow of hydraulic liquid between said ram chamber and said intermediate relief chamber, and means for rotating said second cylinder to vary the effective area of said metering orifice.

27. An hydraulic shock absorber according to claim **26** in which resilient thrust washer means are provided between said first cylinder and one of said end plates.

28. An hydraulic shock absorber according to claim **25** in which the center section and end plates are sealed in respect to each other by gasket means comprising a metal layer sandwiched between a pair of asbestos layers.

29. An hydraulic shock absorber according to claim **25** in which each end plate is provided with mounting means by which the shock absorber can be front or rear mounted in respect to stationary structure.