

Constant displacement shock absorber

FIELD OF INVENTION

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[001] This invention relates to a shock absorber for impulse or sudden thrust of force such as that created by explosive or crashing movement of a mass. Specifically, it concerns hydraulic-pneumatic system of absorbing such shock and translating it into a constant displacement rate in the shock absorber.

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BACKGROUND ART

[002] Shock absorbers are less commonly designed for sudden or impulsive thrust of force that may be exerted in an impulsive movement of an explosive device (e.g. perforating gun, firearm discharge, crashing of a massive object, etc.) or a sustained heavy thrust of force (e.g. halting or terminating movement of a massive object such as parachute landing of a cargo, elevator landing, or passive vehicle braking as seen in shock absorbers between rail cars comprising a train.

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[003] Many of these shock absorbers work on the principle of translating the external shock or force to be absorbed into a constant pressure in a hydraulic shock absorbing mechanism. Key to achieving this constant pressure is the

constant pressure valve such as that disclosed in U.S. Patent No. **4,520,899** (Vasquez) for a shock absorber for parachute landing, or provided by a constant reference pressure of a pneumatic chamber in U.S. Patent No. **4,407,396** (Sirven).

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[004] U.S. Patent No. **4,785,922** (Kiehart) provide such a constant pressure by use of a piston that decreases in diameter as the applied force increases. Alternatively, the valve's opening may be electromagnetically controlled to provide the desirable constant pressure control as disclosed in U.S. Patent No. **4,902,034** (Maguran). Discounting methods of absorbing by permanent material deformation of consummables (such as a string of deformable damping coil or honeycomb for absorbing shock from a perforating gun disclosed in U.S. Patent No. **5,131,470** (Miszewski), in all these conventional methods and devices, due to the sudden and magnitude of the force bearing on conventional shock absorbers, the initial spike in pressure is not overcome.

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[005] This could be seen in the chart of FIGURE 1 (Prior Art) for different pressure loads represented by graphs "a", "b" and "c" before the optimized performance in shock absorbing is achieved at the plateau stage and dissipated at the declining end of the graphs. Curve "d" represents the average pressure for curve "c". Without overcoming the pressure spikes means that excessive pressure are being experienced by the equipment and thus each of the increased and sudden stress would adversely affects the shock absorber or the suspended equipment's fatigue life.

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[006] In a related aspect, a Venturi effect known as choked flow, whereby in response to increasing pressure differential between upstream and downstream of an orifice, the flow rate is increased until a limiting velocity, is shown in
5 FIGURE 3 (Prior Art). This constant flow phenomenon has been used in various applications such as for fluid flow metering and valve control disclosed in U.S. Patent No. **6,250,602** (Janssen's Aircraft) and U.S. Patent No. **7,246,635** (Caleffi), fuel feeding control in carburettors of internal combustion engine such as disclosed in U.S. Patent No. **4,379,770** (Bianchi), flywheel
10 vibration damping disclosed in U.S. Patent No. **5,595,539** (Yamamoto), etc. However, we were unable to find any in the field of shock absorbers.

SUMMARY OF DISCLOSURE

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[007] It is thus desirable to have a shock absorber in which the initial peak pressure is erased by being effectively absorbed into the optimised performance range of the graph as shown in FIGURE 2. FIG. 2 shows the corresponding ideal graphs "a", "b" and "c" in a rectangular or trapezoidal
20 shape. Our invention involves applying the known hydraulic principles known as Venturi effect. Specifically, it involves the fluid dynamics known as the choked flow of a fluid.

[008] Briefly, when a fluid flows through a small opening into a lower

downstream pressure environment, the velocity of the flow will increase as the pressure increase upstream due to Venturi effect. As upstream pressure increase further, the fluid flow velocity will increase until it reaches a limiting velocity called "**choked flow**" whereby further increase in upstream pressure will not increase the velocity any further.

[009] Our method for absorbing shock may be generalized as comprising the steps of:

- (i) transmitting pressure arising from the shock or force to a mass of translation fluid to exert a first pressure;
- (ii) amplifying said first pressure against an enclosed mass of fluid and forcing said fluid to flow through a constricted pathway such that at least one of the amplified pressure and constricted pathway enables choked flow rate of the fluid to leave said mass of fluid;
- (iii) accommodating the fluid from the choked flow in an expandable reservoir; and
- (iv) resisting the expansion of said expandable reservoir with a volume of compressible gas.

[010] In the general embodiment implementing our aforesaid method, an apparatus for absorbing shock may be provided comprising a first piston telescopically mounted into a first cylinder enclosing an inner reservoir; a return spring coaxially mounted between said first piston and first cylinder urging said first piston and first cylinder apart from being telescopically compressed against

each other; at least a nozzle provided through said first cylinder wall enabling fluid communication between said inner reservoir and an external fluid reservoir. The first piston is predisposed to receive pressure acting thereupon by fluid translated from the shock to be absorbed while the fluid is in communication with external fluid reservoir. The first piston is further predisposed to amplify said pressure acting thereupon to bear upon said inner reservoir such that the amplified pressure on the fluid therein overcomes pressure of external fluid reservoir and exit nozzle at about choked flow.

10 [011] In a first aspect of our invention, our apparatus may be further provided with an inner tube providing for telescopic movement between the first piston and a second piston whereupon shock to be absorbed may be imparted to distal end of said second piston and transmitted to said first piston via fluid in a translation reservoir. Preferably, the inner tube is housed in an outer tube
15 defining an annular chamber for external fluid reservoir. The inner tube may preferably have a plurality of holes providing hydraulic communication between the translation reservoir and the annular external fluid reservoir. Preferably still, the plurality of holes are distributed such that the progression of second piston into inner tube incrementally closes more of the holes to providing hydraulic
20 communication between the translation reservoir and the annular external fluid reservoir.

[012] In an alternative embodiment, the plurality of holes is distributed such that the progression of second piston into inner tube incrementally opens the

holes to providing hydraulic back pressure to the second piston. The hydraulic fluid may be provided in continuous communication between translation reservoir, annular external fluid reservoir and inner reservoir through the respective holes and nozzles.

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[013] In a second aspect, the first piston amplifies the pressure acting thereupon to bear upon the inner reservoir by predetermined positive ratio of surface areas of first piston head to first piston end. Preferably, a plurality of nozzles is provided at predetermined nozzle orifice sizes to achieve choked flow rate of fluid ejected therefrom. The positive ratio is preferably sufficiently large for the pressure bearing upon the inner reservoir to eject fluid therein through nozzles at choked flow. A preferred ratio is 4:1. The plurality of nozzles may alternatively be distributed throughout the first cylinder wall whereby the telescopic movement of the first piston into said first cylinder progressively closes the nozzles therealong.

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[014] A third aspect of our invention provides for the external fluid reservoir to be in further hydraulic communication with an expandable reservoir. Preferably, the expandable reservoir comprises a floating piston slidable within a rear chamber divided thereby into said expandable reservoir and a rear reservoir. The rear reservoir is preferably filled with compressible fluid comprising gas or gaseous mixture that is substantially inert such as nitrogen (N_2) and wherein the volume is adjustable according to the compressibility required complementary to the expansion of expandable reservoir. As a specific embodiment, at least

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one of the free floating piston, expandable reservoir and rear reservoir may be configured in hydraulic communicative extension in parallel to the rest of the apparatus's elements in telescopic relation.

5 [015] A fourth aspect of our apparatus provides for the first cylinder to be adapted to slide telescopically into an extended end for receiving shock or direction of force to be absorbed, said first cylinder and extended end provided with counter-biasing spring. Preferably, the force or shock acting on extended end is transmitted to the first cylinder by urging first piston against a translation
10 reservoir comprising hydraulic fluid.

[016] Our shock absorbing apparatus may be comprised in a shock absorber, dashpot, thrust absorber, recoil mechanism, crash impact absorber and the like, and may be used in conjunction or complementary with conventional damping
15 means including any one or combination of hydraulic and/or pneumatic damping, hysteresis damping, electro-magnetic damping, inertial resistance and the like.

LIST OF ACCOMPANYING DRAWINGS

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[017] A better understanding of our invention may be had with reference to the following drawings which illustrate specific, preferred embodiments in non-limiting, exemplary manner and with the detailed description that follows, in which

[018] FIGURE 1 (Prior Art) illustrates a graph chart of shock pressure absorption against displacement of conventional devices in which the initial spike of pressure is inadequately absorbed;

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[019] FIGURE 2 shows a graph chart of an ideal shock pressure absorption such as that achievable by our shock absorber in which the initial spike of pressure is effectively absorbed;

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[020] FIGURE 3 (Prior Art) presents a typical pressure vs flow velocity graph showing sonic or choked flow being reached;

[021] FIGURE 4 illustrates 3 typical contraction stages of one embodiment of the shock absorber according to our invention;

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[022] FIGURE 5 exhibits a second embodiment of our shock absorber in which proximal length portion is configured parallel to shorten overall length;

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[023] FIGURE 6 shows a third embodiment of our shock absorber in which the inner reservoir is reconfigured for direct receiving of shock;

[024] FIGURE 7 illustrates an example of our shock absorber implemented in a lift column for damping landing of elevator car; and

[025] FIGURE 8 exhibits another example of our shock absorber implemented in a bumper of a vehicle.

5 DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[026] While choked flow has been defined above as the limiting condition which occurs when the fluid flow velocity will not increase any further with a further increase in upstream pressure or decrease in the downstream pressure,
10 we would like to point out that for homogenous fluids, the physical point at which the choking occurs for adiabatic conditions is when the flow velocity measured at the plane of exit is at sonic conditions or Mach number = 1 which is generally referred to as "sonic flow". It is important to note that the flow rate can still be increased to supersonic speed ($\text{Mach} > 1$) by increasing the
15 upstream stagnation pressure or modifying the small opening's cross-section to a convergent-divergent nozzle or orifice plate.

[027] Accordingly, the term "**choked flow**" used in this specification refers to the limiting constant velocity flow of fluid regardless if the velocity is subsonic,
20 sonic or supersonic. "**Nozzle**" is used to refer to the particular orifice or opening in which choked flow occurs to distinguish from the other holes or openings in our invention.

[028] Generally and briefly, our shock absorber endeavours to apply the

aforescribed choked flow venturi principle in a method for absorbing shock wherein the force from the shock is first transmitted to a mass of translation fluid to exert a first pressure. By varying the surface areas of the piston heads, this first pressure may be amplified according to Bernoulli principle so that the amplified pressure is sufficient to exert pressure on a mass of fluid enclosed therein through a constricted opening to achieve choked flow of the fluid leaving the enclosed mass of fluid. The choked flow of fluid may be accommodated to flow into an expandable reservoir. This reservoir's expandability may be resisted or biased against by piston means separating an enclosed mass of compressible gas.

[029] For ease of understanding the workings of the aforesaid method, we refer to FIGURE 4, wherein a typical shock absorber according to our invention is shown contracting at various stages in absorbing the pressure from the shock. The key elements of our shock absorber comprises a first piston (40) which is telescopically mounted into a first cylinder (50) thus enclosing or forming an inner reservoir (B) therein. A means for urging or biasing the first piston (40) and first cylinder (50) apart from being telescopically compressed against each other is provided in the form of a return spring (54) coaxially mounted between the first piston (40) and the first cylinder (50). At least a nozzle (55) is provided through the first cylinder (50) wall to enable fluid communication between the inner reservoir (B) and external fluid reservoir (G). In FIG. 4, a plurality of nozzles (55) is shown.

[030] The first piston (40) is predisposed to, or to be configured for, receiving the pressure to be absorbed directly or via translation. If the pressure is received via translation, as in the case of the present embodiment of FIG. 4, it may be translated via a reservoir of fluids such as that shown as translation
5 reservoir (A). Fluid from this translation reservoir (A) may also be in hydraulic communication with external fluid reservoir (G) via a plurality of holes (32) provided on an inner tube (30) within which the first piston (40) may slide.

[031] The first piston (40) is further predisposed or configurable to amplify the
10 pressure received and acting thereupon so that the amplified pressure may act to bear upon the inner reservoir (B) such that the amplified pressure on the fluid therein overcomes pressure of external fluid reservoir (G) and exit nozzle (55) at about choked flow.

[032] It should be noted that the shock pressure to be absorbed need not be
15 transmitted to the first piston (40) as shown in FIG. 4. The pressure may be applied directly on the piston (40) as shown in another embodiment in FIGURE 6 (to be described later) and a skilled person would be able to modify the transmission of force accordingly.

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[033] Back to the embodiment of FIG. 4, a second piston (20) is provided to enclose translation reservoir (A) at the other end of the inner tube (30) opposing the first piston (40). An outer tube (10) is further provided to house the inner tube (30) with an annular chamber comprising the external fluid reservoir.

[034] The inner tube (30) has a plurality of holes (32) providing hydraulic communication between the translation reservoir (A) and the annular external fluid reservoir (G). The holes are distributed in such manner that the progression of second piston (20) into inner tube (30) would incrementally closes more of the holes (32) to providing hydraulic communication between the translation reservoir (A) and the annular external fluid reservoir (G).

[035] In this specification, the term "distal" is used to refer to that end of the shock absorber or a component thereof that is nearer or affixed to the source of the shock or pressure, and the term "proximal" refers to the other end of the shock absorber or component thereof that is to be insulated or suspended from the shock, or affixed to a body to be so suspended.

[036] When the pressure from the shock is received at the distal end of the second piston (20), the second piston (20) moves into translation reservoir (A) and thus compresses the fluid, causing a pressure build-up in the reservoir. This pressure is transmitted to the first piston (40) and moves it inwardly into the first cylinder (50).

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[037] As the inner tube has a plurality of holes (32), as the second piston (20) is moved inwardly into inner tube (30), some of the fluid in the translation reservoir (A) will flow out through these holes into the annular space forming the external reservoir (G). As the piston (20) continues to move into inner tube

(30), the holes (32) preceding the piston (20) are gradually being closed while the holes (32) past the piston (20) are opened, allowing the fluid to flow from the external reservoir (G) into space (E) at the back of the piston.

5 [038] The fluid pressed out of translation reservoir (A) would also flow towards the proximal end of the external reservoir (G) i.e. towards the annular space surrounding the first piston (40) and first cylinder (50). At the terminal end of the external reservoir (G), a hydraulic connection is provided to an expandable reservoir (C) where the fluid would empty into as the pistons (20,
10 40) are further compressed. Expandable reservoir (C) is formed by outer tube (since the inner tube (30) has now ended) and enclosed at the distal end by the end of first cylinder (50) and by a floating piston (60) at the proximal end.

[039] As the pistons (20, 40) are further compressed, the hydraulic fluid
15 squeezed out into the annular external reservoir (G) will be pushed into the expandable reservoir (C) and in turn push the floating piston (60) proximally down the terminal end of the outer tube (10). The floating piston (60) may be biased against the expansion of reservoir (C) by a compressible fluid on the other side of the piston (60), such as a gas filling up a rear reservoir (D) at the
20 terminal end of the outer tube (10). Preferably, the volume of compressible fluid or gas is adjustable according to the compressibility required complementary to the expansion of the expandable reservoir (G).

[040] Ideally, a gas is used to fill up rear reservoir (D) as most gases are

compressible. So that the gas does not reduce its volume overtime through reaction or decomposition, an inert gas is recommended, including nitrogen gas. As a gas-filled expandable reservoir (D) may relatively be voluminous depending on the complementary, to keep the shock absorber design length to
5 desirable dimensions, any one of the floating piston (60), expandable reservoir (G) and rear reservoir (D) may be configured to be in hydraulic communicative extension in parallel to the rest of the apparatus's elements in telescopic relation. An example of such parallel extension is shown in FIGURE 5 wherein the gas-filled rear reservoir (D') is configured in parallel with the outer tube (10)
10 wherein the other components or elements of the shock absorber are disposed.

[041] As the first piston (40) and second piston (20) compress the inner reservoir (B) and the translation reservoir (A) respectively, the pressure build up in inner reservoir (B) will increase until the fluid being pressured out through the
15 nozzles (55) reaches choked flow whereupon any further increase in pressure would not increase the rate of displacement of the fluid into external reservoir (G) and into expandable reservoir (C).

[042] As the external reservoir (G) is also comprises of the hydraulic fluid and
20 hence exert some external pressure when the first cylinder (50) is being compressed to squeeze out the fluid from the inner reservoir, the fluid from the inner reservoir must have higher pressure to be forced out of the nozzles (55) to overcome the external pressure. To achieve choked flow, it is estimated that the ratio of the internal pressure to external pressure should be about 4:1. The

choked flow rate may or may not be at sonic speed. Upon reaching the choked flow rate, the discharge of fluid from the nozzles (55) will occur at a constant rate in spite of higher or continuing increase in pressure.

5 [043] As mentioned before, the first cylinder (50) has a series of nozzles (55) that allow fluid communication between the inner reservoir (B) and external reservoir (G). The series of nozzles (55) are arranged such that they will be closed progressively as the first piston (40) moves inwardly into the first cylinder (50). The progressive closure of the nozzles (55) leaving fewer nozzles open
10 may thus hasten the fluid flow rate's increase to choked flow. As such, in such an embodiment where there is a series of nozzles that may be progressively closed, the nozzle hole size need not be each or sum totalled to enable choked flow at the given shock pressure but may achieve choked flow as the remaining number of open nozzles decreases.

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[044] Using Bernoulli's principle, the first piston's distal head (40a) surface area may be provided in relation to the proximal head (40b) such that the pressure from the distal head is amplified in the desired multiple times to be transmitted at the proximal head (40b) to the fluid in the inner reservoir (B).
20 From the surface area formula of a circle, πr^2 , it is obvious that doubling the radius of the distal head (40a) would quadruple the resultant pressure at the proximal head (40b) as evident from $\pi(2r)^2 = 4\pi r^2$.

[045] The space enclosed in between the first piston (40) and the first cylinder

(50) may be referred to as intermediate reservoir (F) which may also be filled with the same fluid as the other reservoirs. Intermediate reservoir (F) may be provided in hydraulic communication with the external reservoir (G) via large apertures (56) towards the end of the inner tube (30) so that they are closed only upon the first piston (40) reaching the end of the stroke at the end of the inner tube (30).

[046] With our shock absorber, we have found that the initial peak pressure caused by inadequate absorption of the shock impulse which appear as spikes in the graph of FIG. 1 will be damped or delayed due to the fast fluid discharge resulting in the choked flow as a result of the pressure amplification acting on the inner reservoir (B). The resulting softer damping effect is the effective smoothening off of the displacement graph.

[047] When the inner reservoir (B) is compressed, the ratio of the first piston (40)'s distal head (40a) to proximal head (40b) may be designed such that the threshold pressure for reaching choked flow be lowered so as to cover a wider range of shock impulse conditions, particularly the initial impulse. The result of such design is to enable the first piston (40) to move at a constant speed irrespective of the pressure or shock loading within that range. Besides substantially removing the initial pressure peak or spike in the graph of displacement, our shock absorber's relatively long recoil stroke length will be able to dissipate the pressure over a longer period of time and displacement as shown in the chart of FIG. 2.

[048] As mentioned before, the shock pressure need not be transmitted via a translation reservoir (A) before being applied to the inner reservoir (B). FIGURE 6 shows an alternative embodiment whereby the shock pressure is applied directly on the inner reservoir (B). In such an alternative configuration, the first cylinder (50) is adapted into an extended end (22) for directly receiving shock or direction of force to be absorbed. The first piston (40) is disposed to slide telescopically into the first cylinder (50) and both piston (40) and cylinder (50) are being opposingly provided with a counter-biasing spring (54). The force or shock acting on extended end (22) may be transmitted to the first cylinder (50) by urging first piston (40) against a translation reservoir (A') comprising hydraulic fluid. To shorten the length of the shock absorber, the parts of the device for terminally containing displaced fluid and the compressive gas for biasing purposes, i.e. expandable reservoir (C) and rear reservoir (D) respectively, may be provided in an adjacent parallel cylindrical member.

[049] The aforesaid method and construction of our shock absorbing apparatus may thus be advantageously applied or used for damping or absorbing shock or pressure of an impulsive or explosive nature such as a shock absorber, dashpot, thrust absorber, recoil mechanism, crash impact absorber and the like. Such devices may be installed or incorporated in a device, machine, vehicle, armament or installation generally or included as components thereof. Alternatively, our invention may be used in conjunction with or complementary to existing hydraulic and/or pneumatic damping,

hysteresis damping, electro-magnetic damping, inertial resistance and the like.

[050] Some of these applications may be exemplified in FIGURE 7 and
FIGURE 8 which respectively shows the damping the halting or landing of an
5 elevator car and for absorbing crash of vehicles or staggered bumping between
coaches of a train. This is additional to the earlier examples mentioned above
in the Background Art of parachute landing, explosive thrusts, etc.

[051] While we have endeavoured to describe above a number of alternative
10 embodiments or configurations of our invention, many of the parts, components
or elements of our shock absorber as disclosed above may be modified, varied
or substituted with equivalents without departing from the working principles as
understood by a skilled person. These alternatives may be innumerable to be
described and are to be considered as falling within the letter and scope of our
15 invention as defined in the following claims.

CLAIMS

1. An apparatus for absorbing shock comprising:

- a first piston (40) telescopically mounted into a first cylinder (50) enclosing an inner reservoir (B);
- a return spring (54) coaxially mounted between said first piston (40) and first cylinder (50) urging said first piston (40) and first cylinder (50) apart from being telescopically compressed against each other;
- at least a nozzle (55) provided through said first cylinder (50) wall enabling fluid communication between said inner reservoir (B) and an external fluid reservoir (G);

wherein

said first piston (40) is predisposed to receive pressure acting thereupon by fluid translated from the shock to be absorbed;

said fluid being in communication with external fluid reservoir (G);

said first piston (40) is further predisposed to amplify said pressure acting thereupon to bear upon said inner reservoir (B) such that the amplified pressure on the fluid therein overcomes pressure of external fluid reservoir (G) and exit nozzle (55) at about choked flow.

2. An apparatus for absorbing shock according to Claim 1 further provided with an inner tube (30) providing for telescopic movement between the first piston (40) and a second piston (20) whereupon shock to be absorbed may be imparted to distal end of said second piston (20) and transmitted to said first

piston (40) via fluid in a translation reservoir (A).

3. An apparatus for absorbing shock according to Claim 2 wherein the inner tube (30) is housed in an outer tube (10) defining an annular chamber for
5 external fluid reservoir (G).

4. An apparatus for absorbing shock according to Claim 2 wherein the inner tube (30) has a plurality of holes (32) providing hydraulic communication between the translation reservoir (A) and the annular external fluid reservoir
10 (G).

5. An apparatus for absorbing shock according to Claim 4 wherein the plurality of holes (32) are distributed such that the progression of second piston (20) into inner tube (30) incrementally closes more of the holes (32) to providing
15 hydraulic communication between the translation reservoir (A) and the annular external fluid reservoir (G).

6. An apparatus for absorbing shock according to Claim 4 wherein the plurality of holes (32) are distributed such that the progression of second piston
20 (20) into inner tube (30) incrementally opens the holes (32) to provide hydraulic back pressure to said second piston (20).

7. An apparatus for absorbing shock according to Claim 4 wherein hydraulic fluid is in continuous communication between translation reservoir (A), annular

external fluid reservoir (G) and inner reservoir (B) through the respective holes (32) and nozzles (55).

8. An apparatus for absorbing shock according to Claim 1 wherein the first
5 piston (40) amplifies the pressure acting thereupon to bear upon the inner
reservoir (B) by predetermined positive ratio of surface areas of first piston head
(42) to first piston end (44).

9. An apparatus for absorbing shock according to Claim 1 wherein a
10 plurality of nozzles (55) are provided at predetermined nozzle orifice sizes to
achieve choked flow rate of fluid ejected therefrom.

10. An apparatus for absorbing shock according to Claim 8 wherein the
positive ratio is sufficiently large for the pressure bearing upon the inner
15 reservoir (B) to eject fluid therein through nozzles (55) at choked flow.

11. An apparatus for absorbing shock according to Claim 10 wherein the
ratio is at about 4:1.

20 12. An apparatus for absorbing shock according to Claim 9 wherein the
plurality of nozzles (55) are distributed throughout the first cylinder (50) wall
such that the telescopic movement of the first piston (40) into said first cylinder
(50) progressively closes the nozzles therealong.

13. An apparatus for absorbing shock according to Claim 1 wherein the external fluid reservoir (G) is in further hydraulic communication with an expandable reservoir (C).
- 5 14. An apparatus for absorbing shock according to Claim 13 wherein the expandable reservoir (C) comprises a floating piston (60) slidable within a rear chamber divided thereby into said expandable reservoir (G) and a rear reservoir (D).
- 10 15. An apparatus for absorbing shock according to Claim 14 wherein the rear reservoir (D) is filled with compressible fluid.
16. An apparatus for absorbing shock according to Claim 15 wherein the volume of compressible fluid is adjustable according to the compressibility
15 required complementary to the expansion of expandable reservoir (G).
17. An apparatus for absorbing shock according to Claim 15 wherein the compressible fluid comprises gas or gaseous mixture that is substantially inert.
- 20 18. An apparatus for absorbing shock according to Claim 17 wherein the inert gas is nitrogen (N₂).
19. An apparatus for absorbing shock according to Claim 14 wherein at least one of the free floating piston (60), expandable reservoir (G) and rear reservoir

(D) is configured in hydraulic communicative extension in parallel to the rest of the apparatus's elements in telescopic relation.

20. An apparatus for absorbing shock according to Claim 1 wherein the first
5 cylinder (50) is adapted into an extended end (22) for directly receiving shock or
direction of force to be absorbed, for directly receiving shock or direction of
force to be absorbed, said first piston (40) is disposed to slide telescopically into
said first cylinder (50) and both said first piston (40) and cylinder (50) are being
oppositely provided with counter-biasing spring (54).

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21. An apparatus for absorbing shock according to Claim 20 wherein the
force or shock acting on extended end (22) is transmitted to the first cylinder
(50) by urging first piston (40) against a translation reservoir (A') comprising
hydraulic fluid.

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22. An apparatus for absorbing shock according to any one of Claims 1 – 21
used in conjunction or complementary with conventional damping means,
including any one or combination of hydraulic and/or pneumatic damping,
hysteresis damping, electro-magnetic damping, inertial resistance and the like.

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23. An apparatus for absorbing shock according to any one of Claims 1 – 21
comprised in a shock absorber, dashpot, thrust absorber, recoil mechanism,
crash impact absorber and the like.

24. A device, machine, vehicle, armament piece and the like, including components thereof, incorporating an apparatus according to any one of Claims 1 – 21.

- 5 25. A method for absorbing shock comprising the steps of:
- (i) transmitting pressure arising from the shock or force to a mass of translation fluid to exert a first pressure;
 - (ii) amplifying said first pressure against an enclosed mass of fluid and forcing said fluid to flow through a constricted pathway such that at least
10 one of the amplified pressure and constricted pathway enables choked flow rate of the fluid to leave said mass of fluid;
 - (iii) accommodating the fluid from the choked flow in an expandable reservoir; and
 - (iv) resisting the expansion of said expandable reservoir with a volume of
15 compressible gas.
