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Remarks:
The references to the drawing no. 5 are deemed to be deleted (Rule 56(4) EPC).

(54) Recoil absorber

(57) The invention relates to devices which safely absorb recoil energy. The invention provides a recoil absorber (10) suitable for heavy mortars (12) and other firearms, being particularly useful where the weapon (12) is to be mounted on a lightweight vehicle. The device comprising a stationary mass (14) attachable to a light vehicle and a movable mass (16) slidably attached to the stationary mass (14), a first hydraulic cylinder (18) having a cylindrical component (20) and a piston component (22), one of the components (20,22) being rigidly attached to the stationery mass (14) and the remaining component (20,22) being attached in line to the movable mass (16) and an oil restrictor circuit (24) in fluid communication with the first hydraulic cylinder (18).

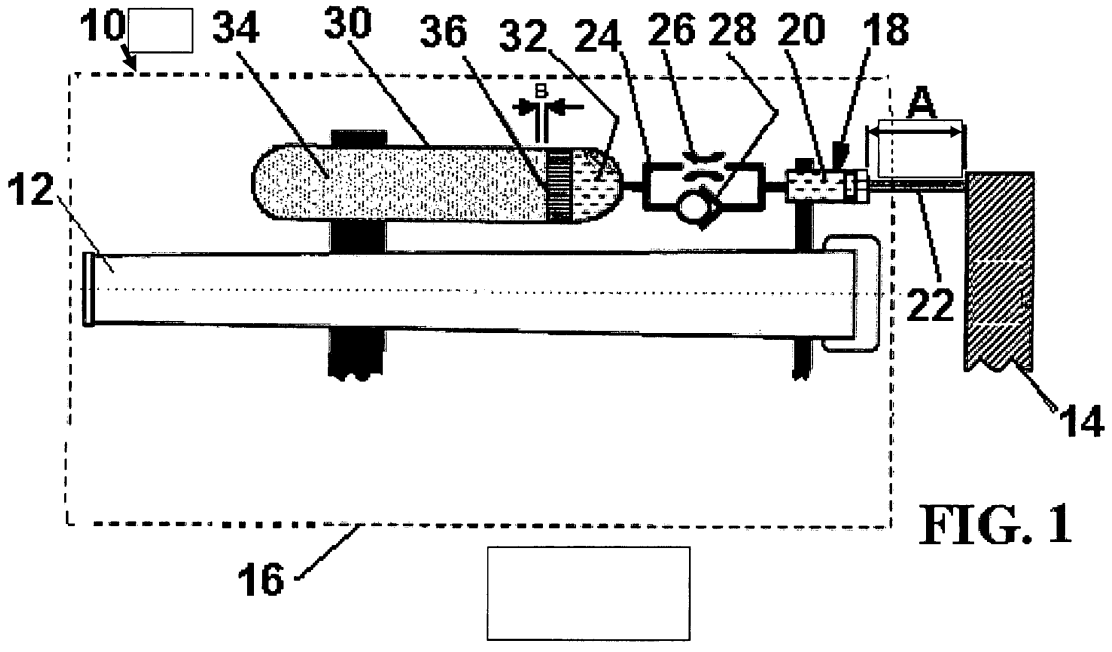

FIG. 1

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Description

[0001] The present invention relates to devices which safely absorb recoil energy.
More particularly, the invention provides a recoil absorber suitable for heavy mortars and other firearms, being particularly useful where the weapon is to be mounted on a lightweight vehicle.

[0002] Military firearms such as heavy mortars and cannons are required to accelerate a heavy projectile containing explosives to reach a high speed when leaving the barrel of the weapon.
The high force required for this task is provided by the detonation of an explosive charge in the chamber of the weapon, and this results in a high reactive force pushing the breech block in a direction opposed to the direction of firing of the projectile. After firing, a relatively small part of the recoil energy is stored in the recuperator to return the recoil mass to its original position. The remaining, bigger part of the recoil energy, has to be absorbed by the buffer. This poses no serious problem for ground mounted guns or mortars, or for ones which are mounted in heavy platforms such as battleships and tanks.

[0003] With the advent of light-vehicle-mounted guns and heavy mortars there followed severe restrictions on the Peak Recoil Force (PRF), as this force was transferred to the vehicle structure and suspension. Aggravating the problem there has been an unceasing operational requirement to increase the range of the gun or mortar, and also to improve the terminal effect of the ammunition, both of which translate to increased PRF.

[0004] Conventional recoil mechanisms meet these requirements, as far as ground operated equipment is concerned. However there is often a further military requirement: the firearm is to be mounted on a light vehicle.

[0005] There are definite limits to the forces which may safely be applied to a light vehicle frame, suspension and wheels. Exceeding these limits or adding a mechanism of excessive weight or applying excessive force will damage the vehicle. Furthermore added weight even within the permissible range will cause deterioration of vehicle performance. For this reason conventional recoil management methods cannot simply be scaled upwards to meet the new requirements and so there is a need for an improved recoil absorption mechanism.

DESCRIPTION OF THE PRIOR ART

[0006] In the prior art two known methods have been used to reduce the PRF for a given muzzle velocity that a projectile of a given mass is to be fired. A first method was to increase the recoil mass. This results in the PRF varying in approximately inverse proportion to the recoil mass. There are obvious limits to this weight increase, aside from the fact that a heavy recoil mass requires a sophisticated recuperator system.
Another method is to allow a longer recoil length, as the PRF approximately varies in inverse proportion to the recoil length. This is in conflict with minimizing the space taken up by the weapon, and furthermore inhibits a high rate of fire due to the increased recoil and retraction time.

[0007] Review of prior art design of recoil mechanisms for artillery guns and heavy mortars (such as described in US patents 7,681,351 6,748,844 6,536,324 5,650,687 5,168,120 4,924,751 4,875,402 4,867,038 4,724,740 4,648,306 4,587,882 2,790,357) reveals that they invariably consist of two main units: buffer and recuperator. The function of the buffer is to brake the recoil movement within a prescribed stroke and with the minimum PRF possible. The function of the recuperator is to return the recoil mass to its initial ("In Battery") position.
The buffer consists of a hydraulic system, in which oil is forced by the recoil movement to flow through a narrow restriction or orifice, often of variable cross section. The viscous resistance to flow produces the braking force and dissipates the kinetic energy of the recoil mass, thus bringing the recoil mass to rest within the prescribed stroke. The average braking force multiplied by the recoil stroke distance equals the kinetic energy dissipated during recoil. In order to minimize the PRF, the braking force offered by the buffer must be as uniform as possible along the recoil stroke. This is the reason for the variable cross section of the restriction or orifice within the buffer. However, high uniformity of braking force along the recoil stroke is very difficult to achieve, because the braking force, which is velocity-dependent, cannot build-up instantly, and because the implementation of variable cross-section restriction or orifice is a very demanding task in terms of design and manufacturing. The recuperator consists of some type of spring - either metallic (usually helical) or a hydro-pneumatic one. During the recoil movement, this spring stores a relatively small part of the recoil-mass kinetic energy, which is then used to return the recoil-mass to in-battery position. The retarding force offered by the recuperator does not substantially improve the uniformity of the braking force opposing recoil.

OBJECT OF THE INVENTION

[0008] It is therefore one of the objects of the present invention to obviate the disadvantages of prior art recoil mechanisms and to provide a recoil arrangement which reduces PRF to enable the firearm to be mounted on a light vehicle.
It is a further object of the present invention to provide a recoil mechanism wherein the resistance force to the recoil is substantially constant during the recoil stroke.

SUMMARY OF THE INVENTION

[0009] The present invention achieves the above objects by providing an improved energy absorber being particularly useful for the control of recoil forces generated during firing of military weapons such as heavy mortar or cannon and the like which is to be vehicle mounted, said absorber comprising

a) a stationary mass attachable to a light vehicle;
b) a movable mass slidably attached to said stationary mass;
c) a first hydraulic cylinder having a cylindrical component and a piston component, one of said components being rigidly attached to said stationery mass and the remaining component being attached in line to said movable mass;
d) an oil restrictor circuit in fluid communication with said first hydraulic cylinder, said circuit comprising a restrictor orifice in parallel to a one-way valve, and arranged so that during a recoil movement said valve is opened by oil forced out of said cylindrical component by said recoil movement;
e) an oil-gas hydraulic cylinder of a diameter substantially larger than the diameter of said first hydraulic cylinder, said oil-gas cylinder being rigidly attached to said movable mass, and being divided by a floating piston into a shorter portion and a longer portion, said shorter portion containing oil, and receiving additional oil from said oil restrictor circuit during recoil, said additional oil being returned after recoil via said restrictor orifice to said first hydraulic cylinder, by means of gas pressure acting on said floating piston, whereas said longer portion contains gas at high pressure. Advantageously the axial floating piston motion during firing of said weapon is less than 20% of the length of the gas-containing portion of said oil-gas cylinder.

PREFERRED EMBODIMENTS OF THE INVENTION

[0010] In a preferred embodiment of the present invention there is provided an energy absorber as claimed in claim 1, further comprising at least one compressible bumper disposed between said stationary mass or a stationary component attached thereto and between said moving mass or a component attached thereto, said bumper being positioned to halt recoil movement in excess of a predetermined allowed stroke.

[0011] In a further preferred embodiment of the present invention there is provided an energy absorber wherein said gas is nitrogen.

In a further preferred embodiment of the present invention there is provided an energy absorber wherein said gas is air.

[0012] In another preferred embodiment of the present invention there is provided an energy absorber wherein a plurality of equally-spaced oil-gas cylinders are attached to said movable mass and are disposed around said barrel assembly of said firearm and parallel thereto.

[0013] In a further preferred embodiment of the present invention there is provided an energy absorber wherein said gas portions of said oil-gas cylinders are interconnected by tubing. Advantageously in this embodiment each section of said tubing includes a shut off valve to allow emergency operation of said firearm where one of said oil-gas cylinders is damaged or is not functional.

[0014] In a further preferred embodiment of the present invention there is provided an energy absorber further provided with a gas recharging port in fluid communication with said gas portion of said oil-gas cylinder, and an oil recharging port in fluid communication with said oil portion of said oil-gas cylinder.

[0015] It will thus be realized that the novel device of the present invention uses the compressed gas to provide a recoil resistance force which remains almost constant over the length of the recoil movement. Consequently the degree of variation of the braking force along the recoil stroke is very moderate and the PRF is considerably reduced, until it becomes almost equal to the average recoil force. This advantage is in contrast with the conventional recoil mechanisms which use hydraulic piston with a variable clearance in order to absorb the recoil energy, suffering from the inherent drawback that the braking force cannot be even close to constant along the recoil stroke, because it is velocity dependent, and cannot instantly build up from zero. Thus the PRF having a substantially lower value in the present invention suffices for absorbing the recoil energy. Thus it is feasible to mount the mortar or cannon on a military or civilian truck from where it can safely be fired without damaging the vehicle.

It should be noted that the initial charging pressure of the gas compartment may be adjusted to stop the recoil mass within the required recoil stroke length. If however the recoil velocity is not absolutely zero the recoil mass will be stopped by the bumper seen in FIG. 2.

The oil restrictor orifice may be adjusted to bring the recoil mass to a complete stop in the retraction phase within the prescribed length which is of course equal to the recoil stroke length. Yet if necessary, front bumpers can be added to stop the retraction movement within its limits.

[0016] The purpose of the oil restrictor orifice requires some further explanation. During recoil, only a small fraction of the kinetic energy of the recoil mass is dissipated in friction and other losses to be converted into heat. Most of the energy is stored as potential energy in the compressed gas, which is later used for the retraction stroke. However it is highly undesirable to use all of this stored energy as this will result in a high velocity of the moving mass towards the end of retraction. Therefore during retraction the oil to be returned is forced to flow through the restrictor orifice where most of the surplus energy is converted into heat while the final velocity of the moving mass will be sufficiently small to avoid damaging the mechanism. This is believed to be a unique feature of the present invention as in prior art most of the kinetic energy is dissipated during the recoil phase and only a minor fraction thereof is stored to be used for retraction. Thus the invention achieves the desired goal of an almost uniform, and therefore minimal, braking force along the recoil stroke, without compromising the important system features of overall weight, overall dimensions and rate of fire.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The invention will now be described further with reference to the accompanying drawings, which represent by example preferred embodiments of the invention. Structural details are shown only as far as necessary for a fundamental understanding thereof. The described examples, together with the drawings, will make apparent to those skilled in the art how further forms of the invention may be realized.

[0018] In the drawings:

FIG. 1 is a schematic view of a preferred embodiment of the recoil mechanism according to the invention;
FIG. 2 is a detail view of an embodiment fitted with a recoil stop bumper;
FIG. 3 is a plan view of an embodiment wherein the moving mass includes four oil-gas cylinders and the moving mass is rail mounted on the fixed mass;
FIG. 4 is a view of a detail showing an arrangement for equalizing the gas pressure in two or more oil-gas cylinders, and;
FIG. 5 is a schematic view of an embodiment wherein the oil-gas cylinder is co-axial with the mortar barrel.

DETAILED DESCRIPTION OF THE DRAWINGS

[0019] There is seen in FIG. 1 an improved energy absorber 10 being particularly useful for the control of recoil forces generated during the firing of a military weapon such as a heavy mortar or cannon 12. The advantages of the present absorber are particularly evident when mounted on a vehicle such as a military or civilian truck (lorry), not shown.

A stationary mass 14, such as the steel framework is seen in FIG 3, is attachable to a platform or floor of the vehicle not shown.

A movable mass 16 is slidably attached to the stationary mass. The moveable mass slides within the Cradle. The Cradle itself is stationary.

A first hydraulic cylinder 18 has a cylindrical component 20 and a piston component 22, one of said components being attached to the stationery mass 14 and the remaining component being attached in line to the movable mass 16.

An oil restrictor circuit 24 is in fluid communication with the first hydraulic cylinder 18. The circuit 24 comprises a restrictor orifice 26, preferably adjustable, in parallel to a one-way valve 28. During the recoil movement A the valve 28 is opened by oil forced out of the cylindrical component 20 by the recoil movement.

An oil-gas hydraulic cylinder 30 has a diameter substantially larger than the diameter of the first hydraulic cylinder 18. The cylinder 30 is positioned in parallel to the barrel of the weapon 12. The oil-gas cylinder 30 is rigidly attached to the movable mass 16, and is divided by a floating piston 36 into a shorter portion 32 and a longer portion 34. The shorter portion 32 contains oil or other hydraulic liquid. During recoil the shorter portion 32 receives additional oil from the oil restrictor circuit, thus moving the floating piston 36 a short distance B and causing a small increase in gas pressure. After recoil the high pressure gas cylinder 30 presses out the additional oil which now flows back to the first hydraulic cylinder 18 via the restrictor orifice 26, whereby the weapon is ready to fire the next round.

[0020] Preferably the axial floating piston 36 motion during recoil of the weapon is less than 20% of the length of the gas-containing portion 34 of the oil-gas cylinder 30. This is readily arranged by choosing suitable diameters for the two cylinders 18, 30.

The preferred gas 34 is nitrogen. However air can be used in circumstances when compressed nitrogen is unavailable.

With reference to the rest of the figures, similar reference numerals have been used to identify similar parts.

[0021] Referring now to FIG. 2, there is seen a detail of an energy absorber 40 further comprising a plurality of compressible bumpers 42 disposed on the stationary mass 44 itself or a stationary component 46 attached thereto. The bumpers 42 are sized to contact the moving mass 48, or a component 50 attached thereto. The bumpers 42 are arranged to halt recoil movement in excess of a predetermined allowed stroke.

[0022] FIG. 3 shows a practical recoil energy absorber 60 wherein a plurality of symmetrically spaced oil-gas cylinders 30 are attached symmetrically around the barrel of the weapon 12.

The cylinders 30 are rigidly connected to the movable mass 16 and are disposed around the barrel assembly 12 of the mortar.

The fixed framework 14 carries rails 62 which slidably support the sleeves of the movable mass 16.

[0023] Seen in FIG. 4 is a portion of an energy absorber 70 wherein the gas portions 34 of the oil-gas cylinders 30 are interconnected by tubing 72. Equalizing the gas pressure in the cylinders 30 is important in achieving symmetry of braking and avoiding the phenomenon known in the art as "barrel jump".

Each section of the tubing 72 includes a shut off valve 74 to allow emergency operation of the firearm where one of the oil-gas cylinders 30 is damaged or is not functional.

In the present embodiment provision is made for the possible loss of fluids in the cylinders 30. A gas recharging port 76 is in fluid communication with the gas portion 34 of the oil-gas cylinder.

[0024] There is further provided an oil recharging port 78 in fluid communication with the oil portion 32 of the oil-gas cylinder 30.

[0025] Referring now to FIG. 5, there is depicted an energy absorber 80 wherein the oil-gas cylinder 30 is disposed in line and in contact with the barrel assembly 12 of the firearm.

The present configuration requires more room in an axial direction than the previous embodiments, but has an im-

portant advantage: there are no side forces which need to be carried. Thus where enough room is available a lighter structure can serve the purpose of supporting the various components of the movable mass 82.

[0026] The scope of the described invention is intended to include all embodiments coming within the meaning of the following claims. The foregoing examples illustrate useful forms of the invention, but are not to be considered as limiting its scope, as those skilled in the art will be aware that additional variants and modifications of the invention can readily be formulated without departing from the meaning of the following claims.

Claims

1. An improved energy absorber being particularly useful for the control of recoil forces generated during the firing of military weapons such as a heavy mortar or cannon and the like which is to be vehicle mounted, said absorber comprising:

   a) a stationary mass attachable to a light vehicle;
   b) a movable mass slidably attached to said stationary mass;
   c) a first hydraulic cylinder having a cylindrical component and a piston component, one of said components being rigidly attached to said stationery mass and the remaining component being attached in line to said movable mass;
   d) an oil restrictor circuit in fluid communication with said first hydraulic cylinder, said circuit comprising a restrictor orifice in parallel to a one-way valve, and arranged so that during a recoil movement said valve is opened by oil forced out of said cylindrical component by said recoil movement;
   and
   e) an oil-gas hydraulic cylinder of a diameter substantially larger than the diameter of said first hydraulic cylinder, said oil-gas cylinder being rigidly attached to said movable mass, and being divided by a floating piston into a shorter portion and a longer portion, said shorter portion containing oil, and receiving additional oil from said oil restrictor circuit during recoil, said additional oil being returned after recoil via said restrictor orifice to said first hydraulic cylinder, by means of gas pressure acting on said floating piston, whereas said longer portion contains gas at high pressure.

2. An energy absorber as claimed in claim 1, further comprising at least one compressible bumper disposed between said stationary mass or a stationary component attached thereto and between said moving mass or a component attached thereto, said bumper being positioned to halt recoil movement in excess of a predetermined allowed stroke.

3. The energy absorber as claimed in claim 1, wherein said gas is nitrogen.

4. The energy absorber as claimed in claim 1, wherein said gas is air.

5. The energy absorber as claimed in claim 1, wherein a plurality of symmetrically-spaced oil-gas cylinders are attached to said movable mass and are disposed around said barrel assembly of said firearm and parallel thereto.

6. The energy absorber as claimed in claim 5, wherein said gas portions of said oil-gas cylinders are interconnected by tubing.

7. The energy absorber as claimed in claim 6 wherein each section of said tubing includes a shut off valve to allow emergency operation of said firearm where one of said oil - gas cylinders is damaged or is not functional.

8. The energy absorber as claimed in claim 1, further provided with a gas recharging port in fluid communication with said gas portion of said oil-gas cylinder.

9. The energy absorber as claimed in claim 1, further provided with an oil recharging port in fluid communication with said oil portion of said oil-gas cylinder.

10. The energy absorber as claimed in claim 1, wherein said oil-gas cylinder is disposed in line and in contact with said barrel assembly of said firearm.

11. The energy absorber as claimed in claim 1, wherein axial floating piston motion during firing of said weapon is less than 20% of the length of the gas-containing portion of said oil-gas cylinder.

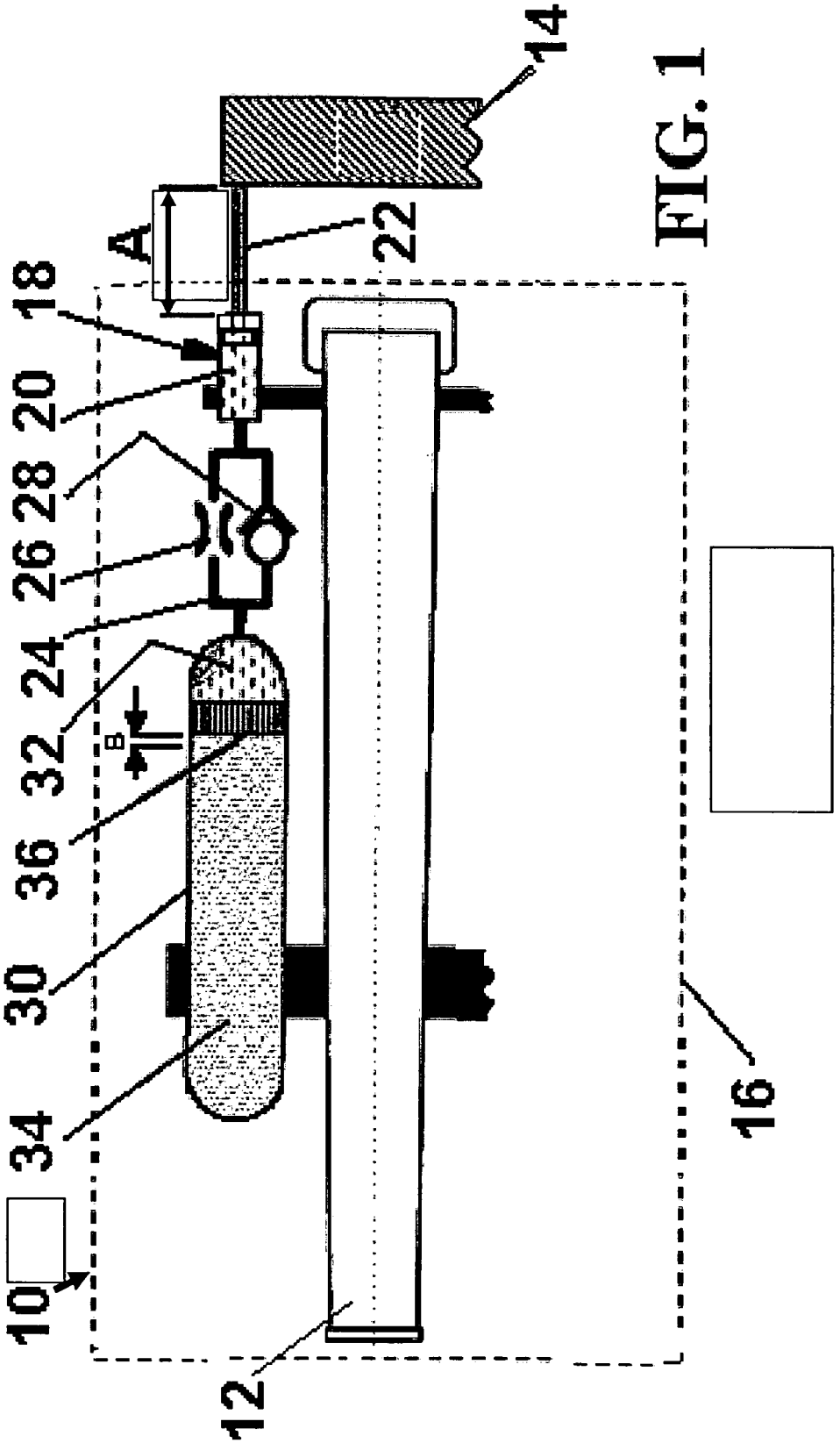
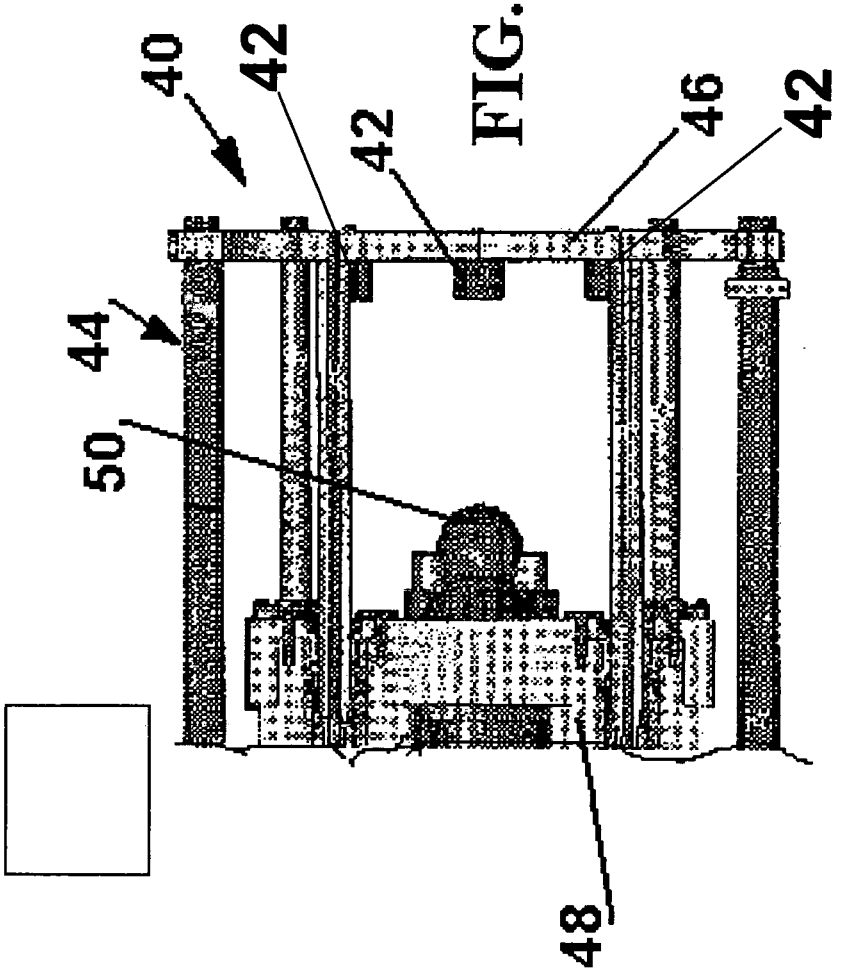


FIG. 1

FIG. 2



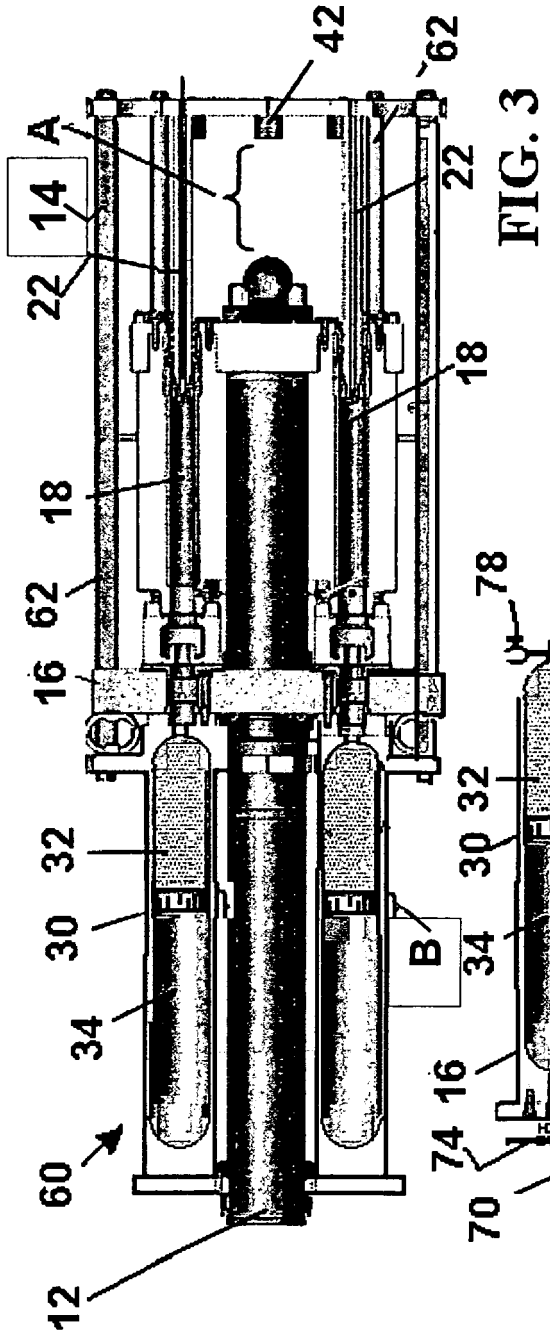

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FIG. 3

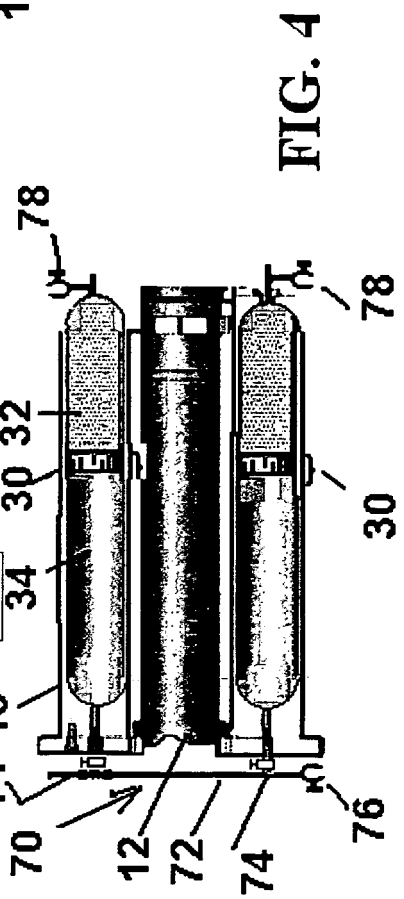
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FIG. 4

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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