DESCRIPTION

TITLE OF INVENTION: ENERGY ABSORBING APPARATUS

TECHNICAL FIELD

Described herein is an energy absorbing apparatus and methods of use. More specifically, apparatus and methods of use are described that utilise varying energy absorbing relationships between the apparatus members to absorb an energy input.

BACKGROUND ART

Energy absorbing apparatus may take a variety of forms, the aim being in a broadest sense, to absorb and/or transfer an energy input by converting the energy in some different manner. One non-limiting example may be to disperse a torque force imposed on a shaft or coupling by transferring the torque force to heat energy, movement of another member, causing a change in gravitational energy, causing a mechanical deformation and so on.

For the purposes of the description below and for brevity, reference will be made to safety apparatus and in particular self retracting lifelines (SRLs) however this should not be seen as limiting. Note that SRLs may also be termed fall limiters, personal fall limiters, yo-yos, road side barrier, road side barrier terminal end, and seatbelts.

SRLs are used in industrial safety applications to prevent falls from height. An SRL typically comprises an extendable and retractable line wound on a spool. The user connects one end of the line to their body, typically via a harness with a connection point. In the event of normal movement, the SRL allows the line to extend and retract. Should a line extension force occur beyond a predetermined rate, the SRL acts to slow and/or stop further line extension. The rapid line extension may be the result of a fall and the slow/stop property of the SRL acts to prevent injury to the user.

For an SRL to be effective, a sudden force generated by a line extension must be rapidly detected and the force absorbed/transferred quickly, and potentially reduced to full

energy transfer (e.g. to a halt motion). Many art devices already exist, often utilising latches or other mechanical interactions between the members to absorb the energy and slow/stop a fall. Potential problems with art SRL devices may be reliability, the art mechanisms utilised in the absorption of energy being susceptible to contamination, environmental decay, deformation, and wear that might be generated from the manufacturing process or use in the field. Such reliability issues demand onerous checking and servicing requirements, and the potential for further harm to users of such art devices. The apparatus described herein may address some of these potential problems or at least provides the public with a choice.

Further aspects and advantages of the energy absorbing apparatus and methods of use should become apparent from the ensuing description that is given by way of example only.

SUMMARY

Described herein are apparatus and methods of use that utilise varying energy absorbing relationships between the apparatus members to absorb an energy input particularly via various metal forming processes.

In a first aspect, there is provided an energy absorbing apparatus comprising:

a first energy producing member;

a second energy absorbing member; and

when an energy input is produced by the first energy producing member that exceeds a predetermined threshold, the second energy absorbing member absorbs at least part of the first member energy via a material forming process.

In a second aspect, there is provided a method of absorbing energy by the steps of:

(a) selecting an energy absorbing apparatus substantially as described above;

(b) applying an energy input on the first energy producing member that exceeds the predetermined threshold thereby triggering the second energy absorbing member to absorb at least part of the first member energy via a material forming

process.

The inventors have established that material forming processes may provide useful ways of absorbing energy. The absorbing noted above may act as an arrest force, slowing or stopping movement of the first energy producing member.

Advantages of the above material forming processes may be varied depending on the final configuration but may include:

- Rapid deployment of an absorbing force beyond a predetermined threshold;
- Rapid absorbing/transfer from part to full energy transfer.
- The apparatus described have an inherent reliability since they are mechanically simple and rely on known and predictable properties of the materials;
- The sudden stop that might be generated from an art latch device can be avoided through material selection and design;
- High density forces may be absorbed;
- The energy absorbing member or parts thereof may be replaced post activation allowing the apparatus to be re-set post activation; and
- The energy absorbing member or parts thereof have a long deformable length (high strain capacity).

BRIEF DESCRIPTION OF THE DRAWINGS

Further aspects of the energy absorbing apparatus and methods of use will become apparent from the following description that is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 illustrates an example of a wire drawing embodiment;

Figure 2 illustrates a potential SRL embodiment utilising wire drawing;

Figure 3 illustrates an alternative potential SRL embodiment utilising wire drawing;

Figure 4 illustrates a linear motion extrusion embodiment;

Figure 5 illustrates a rotational motion extrusion embodiment; and

Figure 6 illustrates a friction welding embodiment.

DETAILED DESCRIPTION

As noted above, described herein are apparatus and methods of use that utilise varying energy absorbing relationships between the apparatus members to absorb an energy input particularly via various metal forming processes.

For the purposes of this specification, the term 'about' or 'approximately' and grammatical variations thereof mean a quantity, level, degree, value, number, frequency, percentage, dimension, size, amount, weight or length that varies by as much as 30, 25, 20, 15, 10, 9, 8, 7, 6, 5, 4, 3, 2, or 1% to a reference quantity, level, degree, value, number, frequency, percentage, dimension, size, amount, weight or length.

The term 'substantially' or grammatical variations thereof refers to at least about 50%, for example 75%, 85%, 95% or 98%.

The term 'comprise' and grammatical variations thereof shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements.

The terms 'rod', 'wire' and 'bar' may be used interchangeably. For brevity, the description below may refer to generally round or circular cross section rods, wires or bars however this should not be seen as limiting since other cross sections may be used and still achieve the same or similar function such as square, oblong or elliptical cross sections. Further, a rod, wire, bar, or similar may be referred to in the singular context, however it will be appreciated that the invention is possible with multiples of such elements in parallel to achieve the desired function and are therefore within the scope of the invention. These multiples may each be of different form, area, and material, to the others, selected to achieve the desired function and performance characteristic.

The term 'member' may refer to one part or element or multiple parts or elements that together achieve the function noted.

In a first aspect, there is provided a device comprising:

at least one moving mass;

at least one energy absorbing member; and

when the at least one moving mass reaches a predefined threshold, the at least one energy absorbing member engages and applies a retarding force on movement of the at least one moving mass, transferring kinetic energy from the at least one moving mass into work energy by plastic deformation of a material associated with the at least one energy absorbing member.

The inventors have established that material forming processes may provide useful ways of absorbing energy. The absorbing noted above may act as an arrest force, slowing or stopping movement of the first energy producing member.

The predefined threshold noted above may be a distance of movement of the moving mass and/or speed/rate of movement of the moving mass.

Engagement noted above may be by coupling of the at least one moving mass and the at least one energy absorbing member.

The retarding force may result in a halt in movement of the at least one moving mass although retarding may also refer to a slowing in speed or rate of movement and not a complete halt in movement.

Prior to engagement, the at least one moving mass may be free to move relative to the at least one energy absorbing member. For example the moving mass may be a spool of line that is free to rotate until the predetermined threshold, for example rapid deployment of line from the spool, at which point coupling and absorption occurs.

An external force may impose motion to the at least one moving mass.

The at least one moving mass may move in a linear direction and the retarding force applied to the at least one moving mass may be a linear force. Alternatively, the at least one moving mass rotates and the retarding force applied to the moving mass may be a torque force.

The retarding force may be applied in a direction substantially opposite that of the moving mass direction of travel.

The rate at which kinetic energy may be absorbed by the at least one energy absorbing member may be related to:

(a) the force or torque applied to the at least one energy absorbing member from the at least one moving mass; and/or

(b) the distance travelled or rotated by the at least one moving mass.

Plastic deformation as noted above may be achieved by methods selected from: wire drawing, deep drawing, tube inversion, and combinations thereof.

Wire drawing is an industrial process where a wire or bar may be reduced in diameter by pulling the bar through a reduced diameter member such as a die with a narrowing waist or shoulder.

Deep drawing or tube inversion are processes are similar in style to wire drawing, that is metal being drawn through a die however, deep drawing refers to drawing a plate and tube inversion is drawing a tube. These processes may be adapted in a similar style as noted above for energy absorbing apparatus as described above.

The wire, sheet or tube used in the methods above may have substantially uniform material characteristics resulting in a substantially linear retarding force being applied to the at least one moving mass.

The term 'uniform characteristics' used above refers to reaching a substantially constant retarding force but optionally including at least one limited duration variation in retarding force e.g. at the time of engagement allowing for an initial increase in retarding force imposition.

Alternatively, the wire, sheet or tube used may have non-uniform material characteristics resulting in a non-linear retarding force being applied to the at least one moving mass.

The material characteristics may be varied along part or all of the wire length, the characteristics being selected from alterations to the: wire/sheet/tube diameter or width, wire/sheet/tube composition, wire/sheet/tube material treatments prior to forming; and combinations thereof.

The force required to pull the wire/sheet/tube through the die may be predictable and is related to the strain energy required to deform the material within the die. Through choice of material, the force required to pull the wire through the die may be tuned. This process may also be capable of absorbing high energy density forces. This may be because:

- The entire volume of the material is strained as it passes through the die;
- The material being worked is confined within the die and is subject to hydrostatic compression forces so high stresses can be sustained;
- The material being deformed may be of high strength, so that a significant amount of strain energy can be generated from a small volume of material.

As noted above, the arrest force profile, being the rate of line speed extension slowing or stopping, may be modulated by pre-forming the wire. For example, the section of wire that initially enters the die may be tapered from a fully formed diameter to an un-formed diameter over a finite length. In addition, the force required to draw the wire through the die may be modulated through for example use of varying materials, use of varying diameters, material treatments prior to forming and the like. As a result of the above variations, the torque exerted on the first energy causing member (e.g. a spool) can be controlled in either a linear or non-linear manner depending on various pre-determined aspects.

In an alternative embodiment, plastic deformation may be by methods selected from: bar bending or controlled buckling where a wire, rod, bar or plate bends or buckles in a predetermined manner to absorb kinetic energy and impose the retarding force. In a rotational embodiment, bending or buckling may be torsional deformation through the act of twisting a wire, rod or bar.

The wire, rod, bar or plate may have substantially uniform material characteristics resulting in a substantially uniform retarding force being applied to the moving mass.

Alternatively, the wire, rod, bar or plate may have non-uniform material characteristics resulting in a non-linear retarding force or forces being applied to the moving mass.

The non-uniform characteristics may comprise multiple layers of material, the layers

having differing deformation moduli therefore providing varying energy absorbing characteristics.

Alternatively, the material forming process may be bar bending or controlled buckling. In these embodiments, a wire, rod, bar or plate may bend or buckle in a predetermined manner when a first member force is applied over a predetermined level. In a further form, this may be bending in the rotational sense, commonly referred to as torsional deformation through the act of twisting a wire, rod or bar. The degree of material strain may govern the rate of energy absorbing. In this embodiment, the amount of strain may vary through the thickness of the material and as a result, the degree of energy absorbing may be tuned. For example, multiple layers of material may be used, the materials having differing moduli of elasticity therefore providing varying energy absorbing characteristics.

In a further alternative embodiment, plastic deformation may be by slitting or shearing where a wire or bar is slit or sheared through to absorb kinetic energy and impose the retarding force. In this embodiment a wire, rod or bar may be slit or sheared through in the event of a predetermined force being imposed on the second energy absorbing member.

In a further embodiment, plastic deformation may be by extrusion using a material that re-crystallises at room temperature. Further, plastic deformation may be by extrusion using a material that becomes deformable under energy loading. In both of these embodiments, the methods alone or together absorb kinetic energy and impose the retarding force. The material used for deformation may depend on whether the embodied item is a single use device or multiple use device. Single use devices may use materials that permanently deform, examples including metals or metal alloys and/or plastics. If the intention is to design a multi-use device, then having a material that has properties that remain unchanged or return to an original position post deformation (via a material memory for example) may be useful. Examples of multi-use materials may include rubber, gels or metals that recrystalise. In one embodiment, the material may be lead or lead alloy.

The material may be formed as a wire with a bulged element that passes through a

confined volume relative to the extrudable material shape and size. In a linear motion embodiment, the bulged portion may be a rod enclosed within a housing and when relative movement occurs between rod and housing, the bulged portion is forced into a more confined region of the housing. Alternatively, in a rotational motion embodiment, the bulged portion is formed inside a housing, the housing being formed from co-rotating, different speed elements or counter rotating elements and a circular opening between the rotating elements in which the extrudable material is housed; and wherein when relative rotation occurs between the elements, the extrudable material is forced into a more confined spacing causing material forming to occur and retarding relative motion between the elements.

In a further embodiment, plastic deformation may be by friction welding. Friction welding may be achieved for example whereby the at least one moving mass is a rotating bar that may engage a stationary reaction bar acting as the energy absorbing member via axial loading and, when the mass and member meet, friction between the two surfaces caused by axial loading results in sufficient heat to weld the two components together and the retarding force is achieved by adhesion of the absorbing member during the welding process. The rate of retarding force applied to the moving mass may be substantially uniform. Alternatively, the rate of retarding force applied to the at least one moving mass may be non-uniform achieved by varying the materials used and the rate of the at least one moving mass movement or the applied level of axial load. In an SRL embodiment for example, the fall detection mechanism may activate axial loading of the welded components by triggering the application of a spring force. This embodiment may be useful in order to allow easy resetting of the SRL – for example by removing and replacing the welded components after the fall event.

In a second aspect, there is provided a method of absorbing energy by the steps of:

(a) selecting a device substantially as described above;

(b) applying a motion causing energy input on the at least one moving mass that exceeds the predefined threshold thereby triggering the at least one energy absorbing member to absorb at least part of the at least one moving mass kinetic energy via a material forming process.

Final embodiments for the device described herein may be varied. For example, an autobelay or self retracting lifeline (SRL) embodiment may use the energy absorbing mechanisms. In an SRL embodiment, a line may extend and retract from the SRL device and when the line extends from the SRL device at a rate beyond a predefined threshold, the energy absorbing member engages and applies a retarding force on the rate of line extension, transferring kinetic energy from the line into work energy by plastic deformation of a material associated with the energy absorbing member. SRL and autobelay applications should not be seen as limiting since the devices described may be used for a wide variety of other applications, non-limiting examples including speed control or load control of:

- a rotor in a rotary turbine;
- exercise equipment e.g. rowing machines, epicyclic trainers, weight training equipment;
- roller-coasters and other amusement rides;
- Elevator and escalator systems;
- evacuation descenders and fire escape devices;
- conveyer systems:
- rotary drives in factory production facilities;
- materials handling devices such as conveyer belts or a braking device in a chute;
- roadside safety systems e.g. the energy absorber may be connected in a system to provide crash attenuation though the dissipation of energy via the energy absorber e.g. a roadside barrier or roadside barrier terminal end;
- seat belts in vehicles;
- zip lines;
- braking mechanisms for trolleys and carriages;
- Bumpstops in transport applications;
- Bumpstops in crane applications;
- Torque or force limiting devices in mechanical drive train;
- Structural overload protection in wind turbines;
- Load limiting and energy dissipation in structures, buildings and bridges.

Advantages of the above material forming processes may be varied depending on the final configuration but may include:

- Rapid deployment of an absorbing force beyond a predetermined threshold;
- Rapid absorbing/transfer from part to full transfer.
- The apparatus described have an inherent reliability since they are mechanically simple and rely on known and predictable properties of the materials;
- The sudden stop that might be generated from an art latch device can be avoided through material selection and design;
- High density forces may be absorbed; and
- The energy absorbing member or parts thereof may be replaced post activation allowing the apparatus to be re-set post activation.

The embodiments described above may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more said parts, elements or features.

Further, where specific integers are mentioned herein which have known equivalents in the art to which the embodiments relate, such known equivalents are deemed to be incorporated herein as of individually set forth.

WORKING EXAMPLES

The above described energy absorbing apparatus and methods of use are now described by reference to specific examples.

EXAMPLE 1

Figure 1 shows the principle of wire drawing. The energy absorbing member generally indicated by arrow 1 may be a wire or rod 2 of a varying diameter 2A, 2B. The wire 2 passes through a waisted die 3 in direction X when an energy input is imposed on the

wire 2, and in doing so, wire 2 drawing occurs through the waisted die 3 causing the wire 2 to deform by a reduction in diameter through the die 3. This reduction in area through the deformation of the wire absorbs energy.

EXAMPLE 2

Figure 2 shows an SRL embodiment with the wire or bar 2 noted in Example 1 attached to the rim 10 of a disc 11 that is normally stationary during the extension/retraction operation of a spool (not shown) on which a line (not shown) is attached. If a fall occurs, the rapid rate of increase in line extension (the first energy producing member) causes movement of the spool. An activation mechanism connects the spool to the disc 11 (the second energy absorbing member), causing the disc 11 to spin and in turn drawing the wire 2 through the die 12. The resulting material forming process absorbs the fall energy and thereby slows (or stops) pay out of the line.

EXAMPLE 3

Alternatively, as shown in Figure 3, the SRL may have a rotating disc 20 and the die 21 forms part of / is integrated into the rotating disc 20. The unformed wire 2 is coiled around the disc 20 and a free end is anchored to an SRL housing 22. When an energy input is applied to the rotating disc 20 beyond the predetermined level, the wire 2 is forced through the die 21 thereby causing material forming to occur.

EXAMPLE 4

Metal forming may instead be completed via extrusion. Figure 4 illustrates an extrusion embodiment using a first energy producing member 30, supported in a housing 30a. The housing 30a and first energy producing member 30 encloses a second energy

absorbing member 31, in Figure 4 shown as an elongated rod with a bulge 32 region. The first energy absorbing member 30 may be manufactured from a malleable material such as lead.

An energy input may be produced by the housing 30a moving when subject to an applied force. When this input is below a predetermined threshold, the energy absorbing member 30 does not deform and hence prevents movement of the housing 30a about the bulge 32 region. Should the energy input exceed a predetermined threshold, the first energy absorbing member 30 – the lead– deforms about the bulge 32. This forces the bulge 32 material into a more confined space within the housing 30a and in doing so, absorbs at least part of the first member 30 and housing 30a energy via a material forming process.

EXAMPLE 5

Figure 5 shows an alternative extrusion embodiment to Example 4. Example 4 and Figure 4 above illustrate a linear or generally linear movement direction of the housing 30. A rotational approach may instead be used as shown in Figure 5 using a first energy producing member 41 supported within a housing 40. The housing 40 and first energy producing member 41 enclose a second energy absorbing member 42, in Figure 5 shown as an annulus with two bulge portions 43 about the circumference. The energy absorbing member 42 may be made from a malleable material such as lead. An energy input may be produced by the housing 40 rotating when subject to an applied force. When this input is below a predetermined threshold, the first energy absorbing member 42 does not deform and hence prevents movement of the housing 40. If the energy input exceeds a predetermined threshold, the first energy absorbing member 42 deforms about the bulges 43. This forces the bulge 43 material into a more confined space within the housing 40 and in doing so, absorbs at least part of the first member 41 and housing 40 energy via a material forming process.

EXAMPLE 6

Alternatively, the material forming process may be via friction welding. Figure 6 illustrates one means for achieving metal forming. As shown in Figure 6, a spool 50 (the first energy producing member) with extendable line 51 on it, is linked to a rotating bar 52 axially aligned with a stationary bar 53, the rotating bar 52 and stationary bar 53 being the energy absorbing member.

In normal operation the rotating bar 52 and stationary bar 53 are not connected. In the event of a predetermined threshold being reached, the rotating bar 52 is axially loaded against the stationary bar 53 by axial movement of the stationary bar 53 or rotating bar 52. When the rotating bar 52 and stationary bar 53 surfaces meet, the friction between the two surfaces may, through material selection, rate of member 52, 53 movement and so on, result in sufficient heat to weld the two components 52, 53 together. As welding occurs, the rotating component 52 will experience a braking force caused by adhesion to the stationary component 53, energy therefore being absorbed during the welding process. In an SRL embodiment, the fall detection mechanism may activate axial loading of the components 52, 53, for example, by triggering the axial movement via a spring force. Post welding, the components 52, 53 may be removed and replaced with new separate parts 52, 53.

Aspects of the energy absorbing apparatus and methods of use have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope of the claims herein.

CLAIMS

Claim 1: A device comprising:

at least one moving mass;

at least one energy absorbing member; and

when the at least one moving mass reaches a predefined threshold, the at least one energy absorbing member engages and applies a retarding force on movement of the at least one moving mass, transferring kinetic energy from the at least one moving mass into work energy by plastic deformation of a material associated with the at least one energy absorbing member; and

wherein plastic deformation is by methods selected from: wire drawing, deep drawing, tube inversion, controlled buckling, slitting or shearing, by extrusion using a material that re-crystallises at room temperature, by extrusion using a material that becomes deformable under energy loading thereby absorbing kinetic energy and imposing the retarding force, and combinations thereof.

Claim 2: The device as claimed in claim 1 wherein engagement is by coupling of the at least one moving mass and the at least one energy absorbing member.

Claim 3: The device as claimed in claim 1 or claim 2 wherein the retarding force results in a halt in movement of the at least one moving mass.

Claim 4: The device as claimed in any one of the above claims wherein, prior to engagement, the at least one moving mass is free to move relative to the at least one energy absorbing member.

Claim 5: The device as claimed in any one of the above claims wherein an external force imposes motion to the at least one moving mass.

Claim 6: The device as claimed in any one of the above claims wherein the at least one moving mass moves in a linear direction and the retarding force applied to the at least

one moving mass is a linear force.

Claim 7: The device as claimed in any one of claims 1 to 5 wherein the at least one moving mass rotates and the retarding force applied to the moving mass is a torque force.

Claim 8: The device as claimed in any one of the above claims wherein the retarding force is applied in a direction substantially opposite that of the moving mass direction of travel.

Claim 9: The device as claimed in any one of the above claims wherein the rate at which kinetic energy is absorbed by the at least one energy absorbing member is related to:

(a) the force or torque applied to the at least one energy absorbing member from the at least one moving mass; and/or

(b) the distance travelled or rotated by the at least one moving mass.

Claim 10: The device as claimed in any one of the above claims wherein the wire, sheet or tube used has substantially uniform material characteristics resulting in a substantially linear retarding force being applied to the at least one moving mass.

Claim 11: The device as claimed in any one of claims 1 to 9 wherein the wire has non-uniform material characteristics resulting in a non-linear retarding force being applied to the at least one moving mass.

Claim 12: The device as claimed in claim 11 wherein the material characteristics are varied along part or all of the wire length are selected from: wire diameter, wire composition, wire material treatments prior to forming; and combinations thereof.

Claim 13: The device as claimed in any one of claims 1 to 9 wherein, in a rotational embodiment, buckling is torsional deformation through the act of twisting a wire, rod or bar.

Claim 14: The device as claimed in claim 12 or claim 13 wherein the wire, rod, bar or plate has substantially uniform material characteristics resulting in a substantially uniform retarding force being applied to the moving mass.

Claim 15: The device as claimed in claim 12 or claim 13 wherein the wire, rod, bar or plate has non-uniform material characteristics resulting in a non-linear retarding force or forces being applied to the moving mass.

Claim 16: The device as claimed in claim 15 wherein the non-uniform characteristics comprise multiple layers of material, the layers having differing deformation moduli therefore providing varying energy absorbing characteristics.

Claim 17: The device as claimed in any one of claims 1 to 9 wherein the material is lead or lead alloy.

Claim 18: The device as claimed in any one of claims 1 to 9 wherein the material is formed as a rod with a bulged element that passes through a confined volume relative to the extrudable material shape and size.

Claim 19: The device as claimed in any one of claims 1 to 9 and 18 wherein, in a linear motion embodiment, the bulged element is a rod enclosed within a housing and when relative movement occurs between rod and housing, the bulged element is forced into a more confined region of the housing.

Claim 20: The device as claimed in any one of claims 1 to 9 and 18 wherein, in a rotational motion embodiment, the bulged element is formed inside a housing, the housing being formed from co-rotating, different speed elements or counter rotating elements and a circular opening between the rotating elements in which the extrudable material is housed; and wherein when relative rotation occurs between the elements, the extrudable material is forced into a more confined spacing causing material forming to

occur and retarding relative motion between the elements.

Claim 21: An SRL device comprising:

a line that extends and retracts from the SRL device;

a device as claimed in any one of the above claims coupled to the line; and

when the line extends from the SRL device at a rate beyond a predefined threshold, the device engages and applies a retarding force on the rate of line extension, transferring kinetic energy from the line into work energy by plastic deformation of a material associated with the energy absorbing member.

Claim 22: An SRL device comprising:

a line that extends and retracts from the SRL device coupled to a device with at least one moving mass attached to one end of the line, the opposing end of the line or part thereof being coupled to at least one energy absorbing member; and

when the line extends from the SRL device at a rate beyond a predefined threshold, the at least one energy absorbing member engages and applies a retarding force on the rate of line extension, transferring kinetic energy from the line into work energy by plastic deformation of a material associated with the energy absorbing member; and

wherein plastic deformation is by friction welding.

Claim 23: The device as claimed in claim 22 wherein the at least one moving mass is a rotating bar that engages a stationary reaction bar acting as the energy absorbing member via axial loading and, when the mass and member meet, friction between the two surfaces caused by axial loading results in sufficient heat to weld the two components together and the retarding force is achieved by adhesion of the absorbing member during the welding process.

Claim 24: The device as claimed in claim 22 wherein the rate of retarding force applied to the moving mass is substantially uniform.

Claim 25: The device as claimed in claim 22 wherein rate of retarding force applied to the at least one moving mass is non-uniform achieved by varying the materials used and the rate of the at least one moving mass movement.

Claim 26: A method of absorbing energy by the steps of:

a. selecting a device as claimed in any one of claims 1 to 21;
b. applying a motion causing energy input on the at least one moving mass that exceeds the predefined threshold thereby triggering the at least one energy absorbing member to absorb at least part of the at least one moving mass kinetic energy via a material forming process.