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(54) ORDNANCE DEVICE FOR LAUNCHING FAILURE PRONE FRAGMENTS

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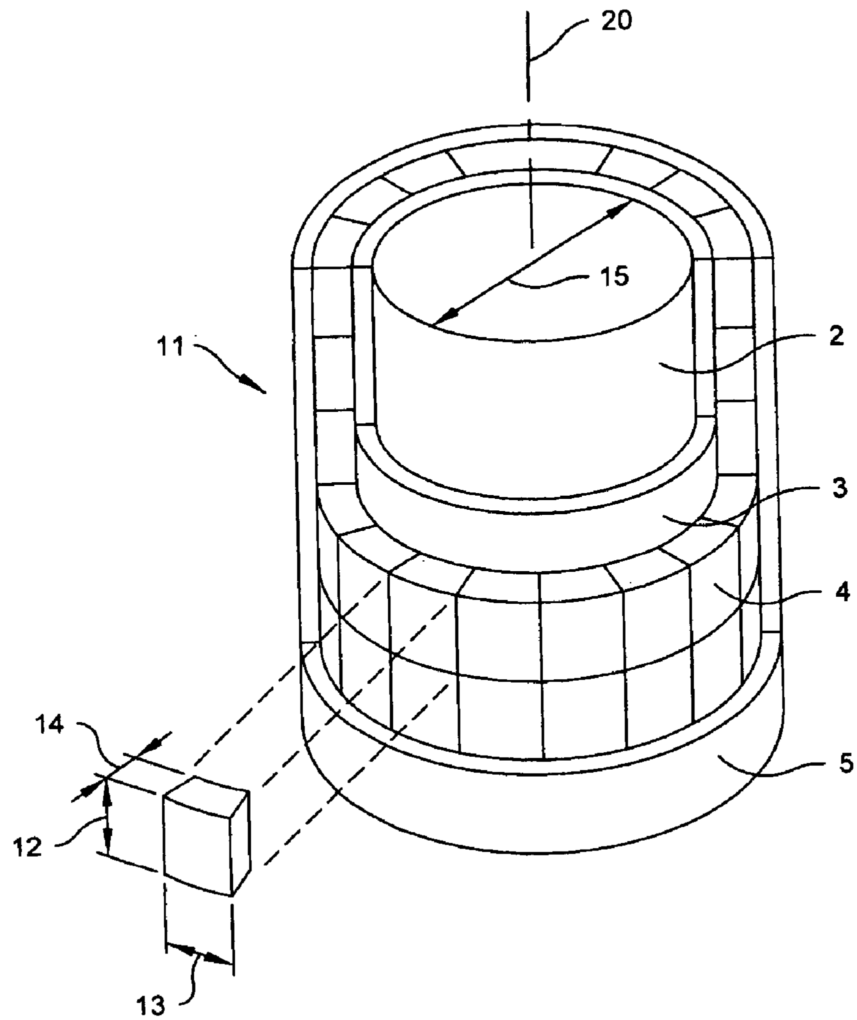
(57) **ABSTRACT**

The present invention is an ordnance device capable of launching discrete failure prone fragments in a coherent, controllable fashion. The described device is comprised of an explosive charge, a buffer element, a plurality of preformed failure prone fragments, and a wrap element in the described order. Buffer element separates failure prone fragments from the explosive charge so as to protect the fragments from damage by explosive detonation products and to reduce an incident pressure wave communicated into the fragments by the detonation. Wrap element further reduces the pressure within fragments by imparting a compressive pulse into the fragments thereby offsetting the negative phase of the incident pressure wave.



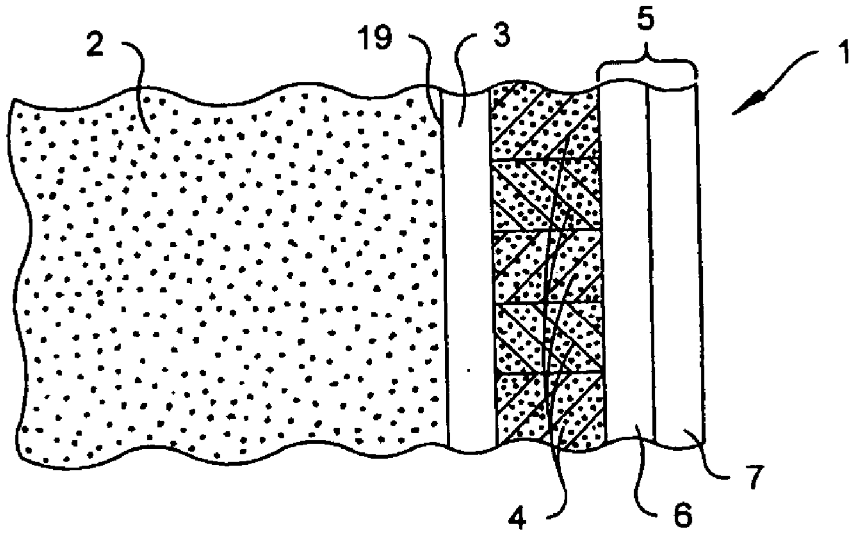


Fig. 1

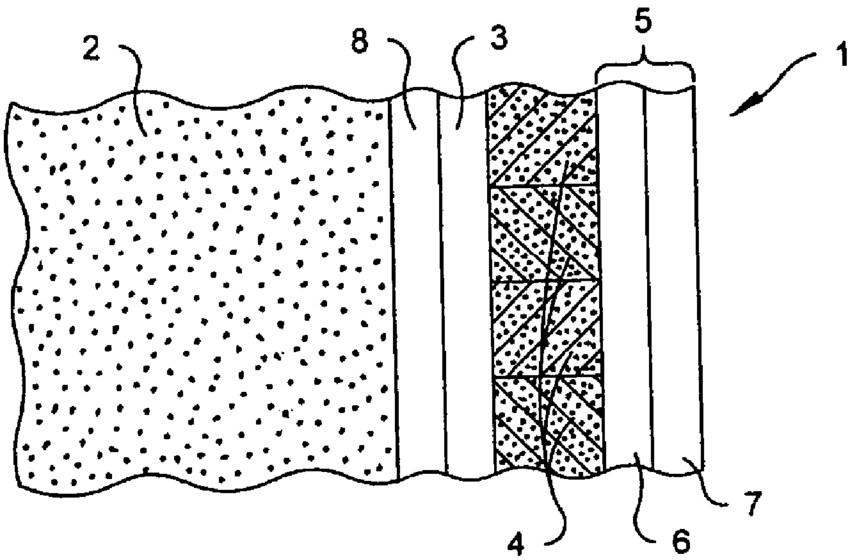


Fig. 2

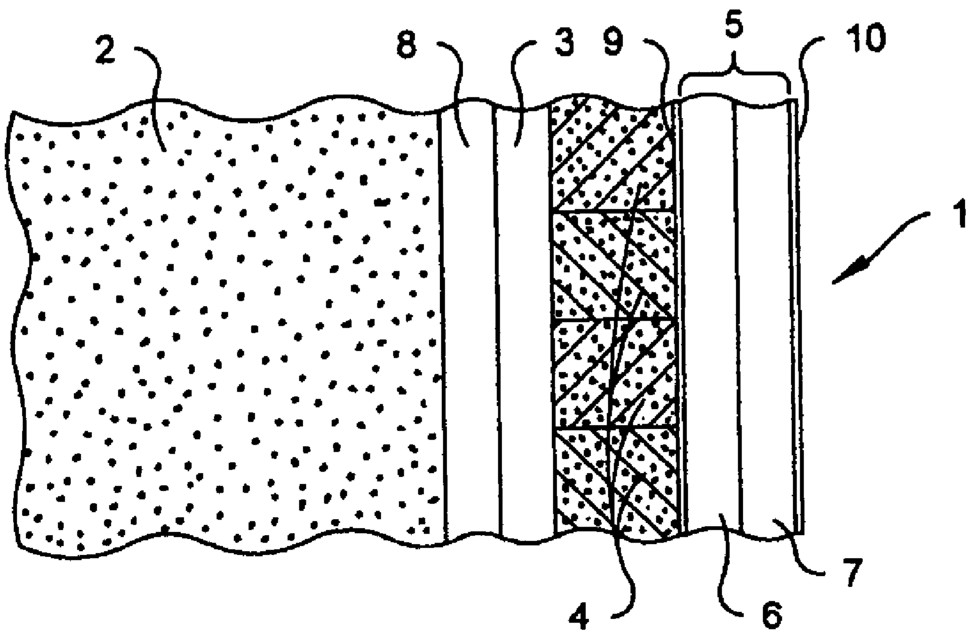


Fig. 3

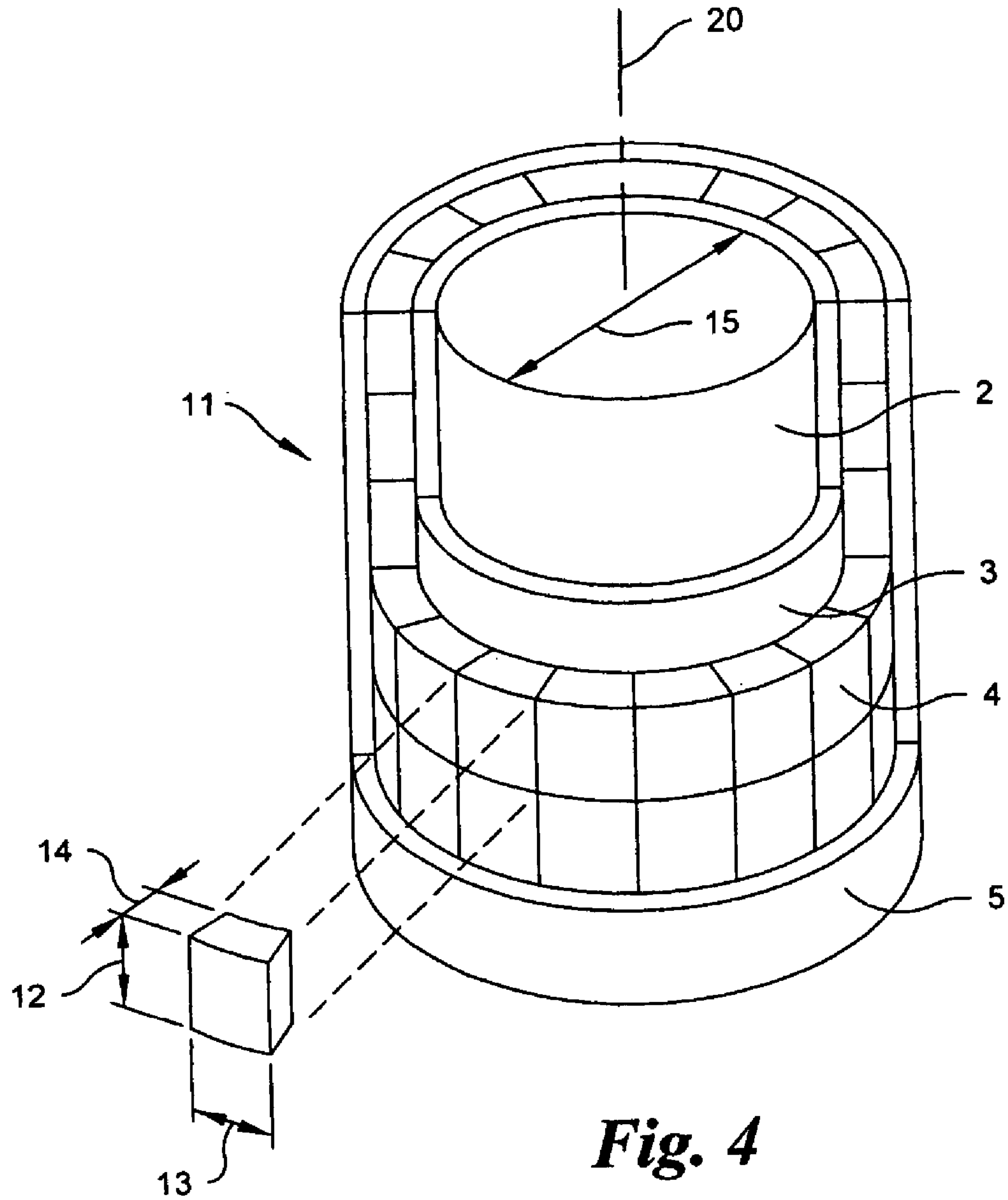


Fig. 4

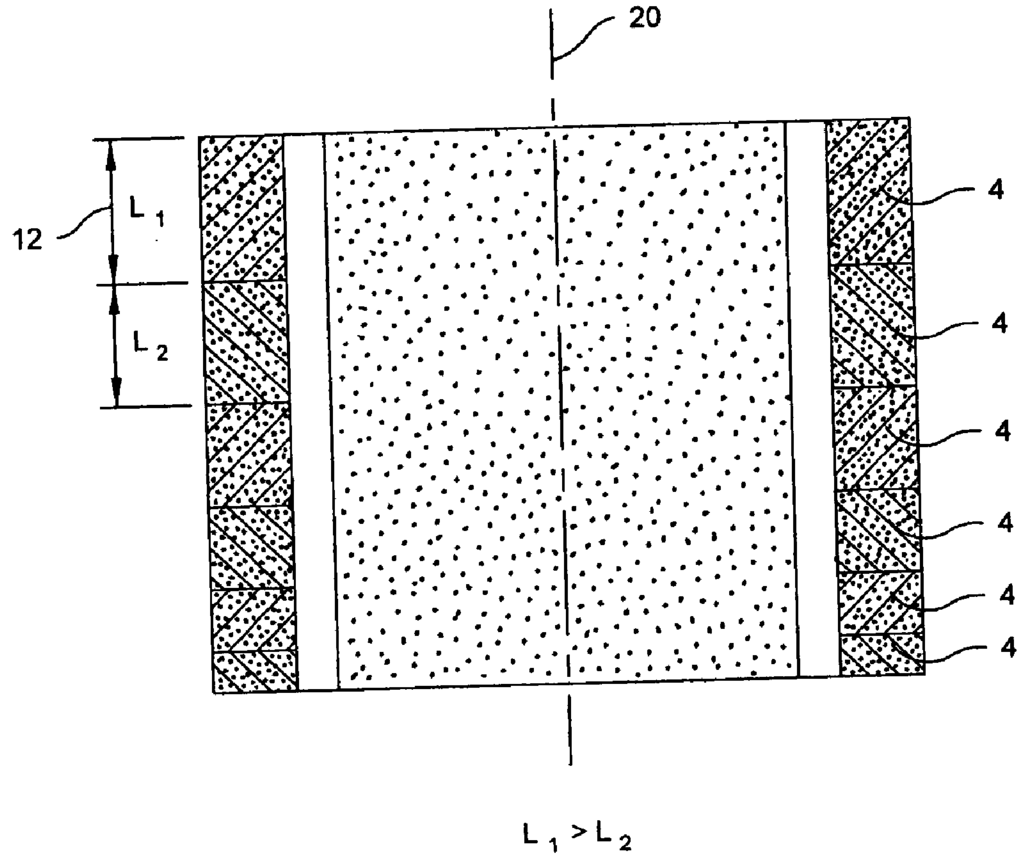


Fig. 5

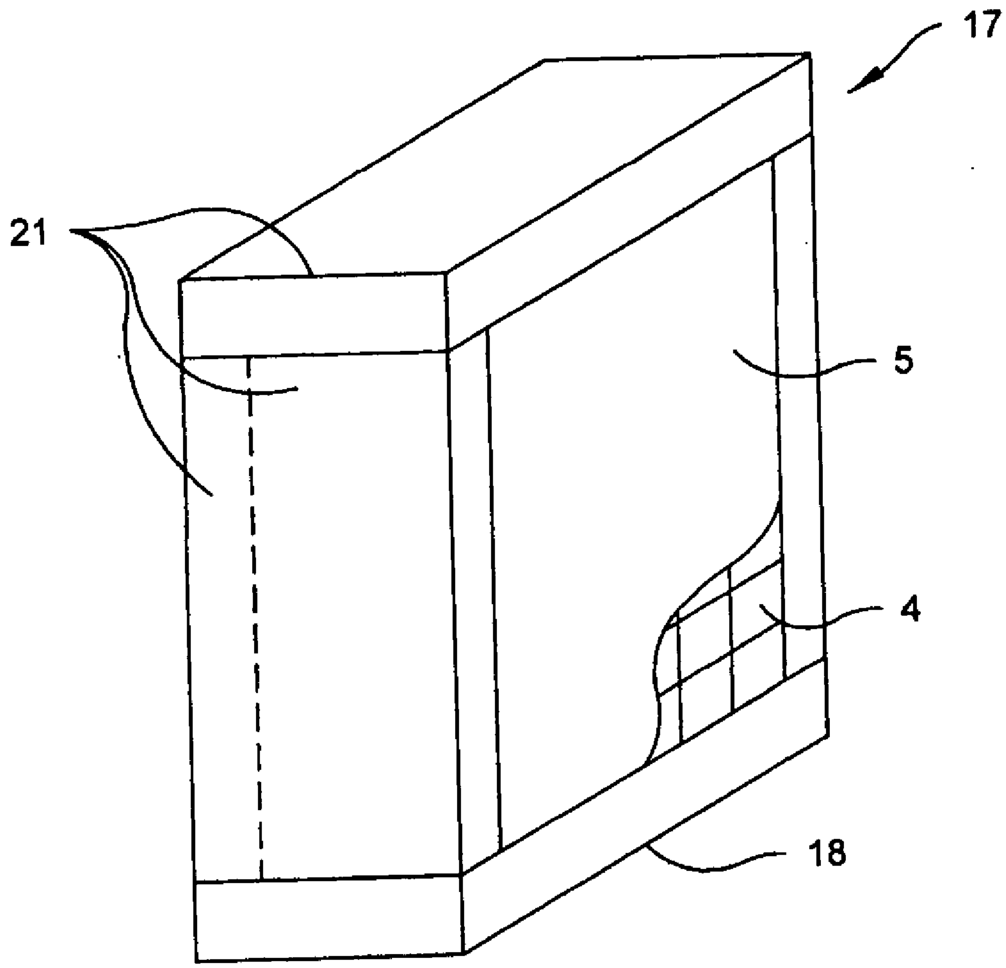


Fig. 6

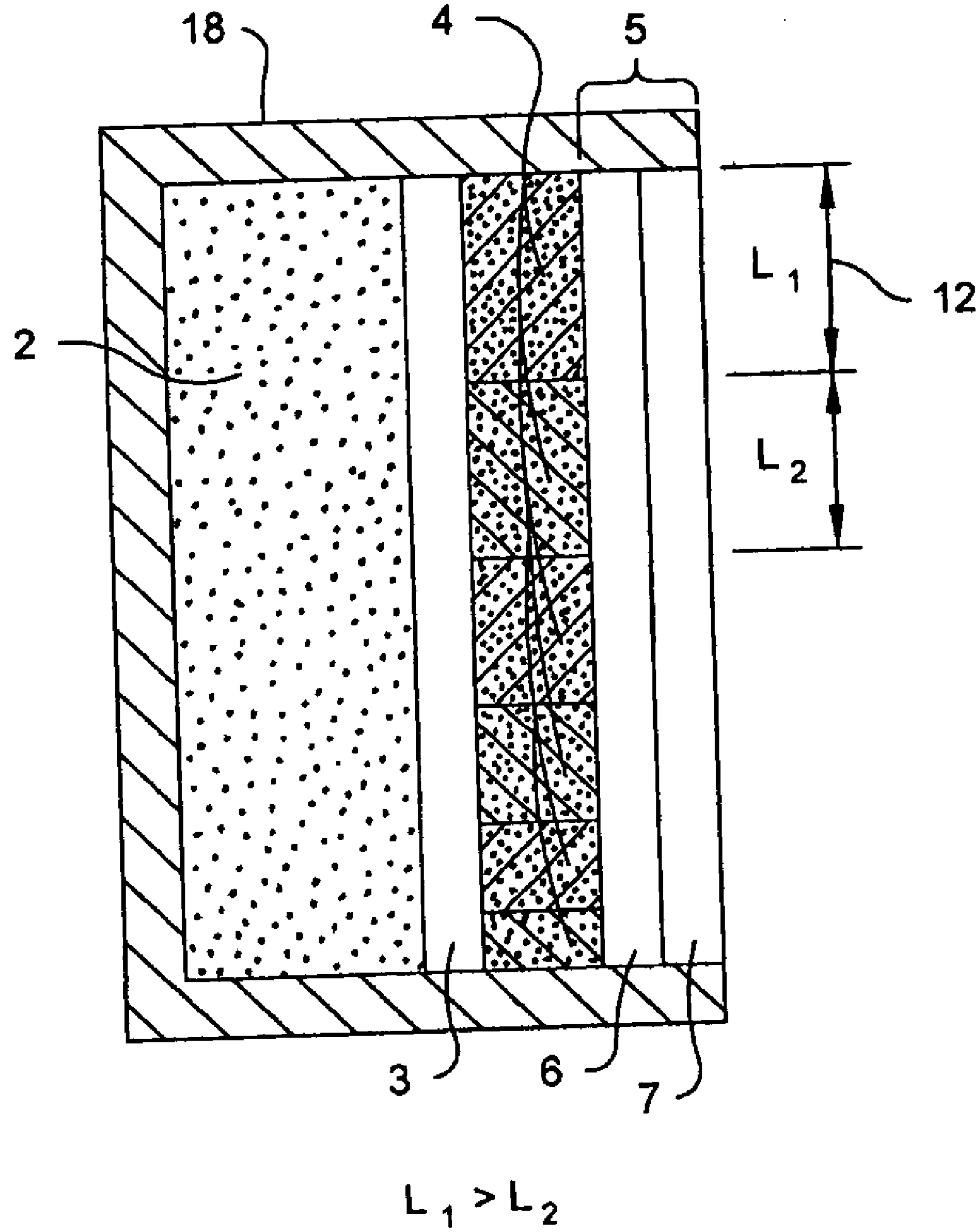


Fig. 7

ORDNANCE DEVICE FOR LAUNCHING FAILURE PRONE FRAGMENTS

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0001] The invention described herein may be manufactured and used by and for the Government of the United States of America for Governmental purposes without the payment of any royalties thereon and therefore.

CROSS REFERENCE TO RELATED APPLICATIONS

[0002] None.

BACKGROUND OF THE INVENTION

[0003] 1. Field of the Invention

[0004] The present invention generally relates to an ordnance device for launching failure prone fragments in a coherent fashion. Specifically, the invention described herein mitigates launch-induced conditions within and along such fragments.

[0005] 2. Background

[0006] A typical ordnance device explosively launches a plurality of inert fragments in a controlled fashion so as to insure impact between one or more fragments and a target. Inert fragments are typically composed of a strong, non-brittle material to insure coherent launch. Fragment strength limits the deposition of kinetic energy within a target to a small volume immediately surrounding the penetration path of the fragment.

[0007] In comparison, failure prone fragments produce a large damage volume within a target thereby increasing the likelihood of catastrophic damage. A failure prone fragment, for example a fluorine-based polymer matrix with metal powder disposed therein, may deposit both kinetic and chemical energies into a target to achieve a large damage volume. Likewise, a failure prone fragment may be composed of a brittle, inert composition, for example a tungsten/metal matrix composite, which fractures and disperses upon impact to achieve a large damage volume. Lethality enhancements are achieved by avoiding fracture and/or reaction during launch in favor of rapid mechanical failures and/or chemical reactions upon impact.

[0008] The mechanical properties of non-brittle, inert fragments resist damage associated with the harsh conditions of an explosive launch. Upon ignition of an explosive, a detonation wave expands through an explosive charge sweeping across the fragments and imparting a shock wave into each fragment. Thereafter, individual fragments are accelerated as the shock traverses the fragment. Reflected shocks and rarefactions are imparted into the fragment after the shock reaches surfaces along the fragment and thereafter superimposed on the incident shock creating a complex pressure state wherein tensile and compressive forces coexist.

[0009] Failure prone fragments are inherently more difficult to explosively launch in a coherent fashion making their application problematic in practical ordnance systems. Polymer-based fragments in particular are less mechanically robust than homogeneous metals. For example, PTFE-metal compositions are reported to have a yield strength at least one order of magnitude lower than metals, thereby susceptible to stress related failures. Additionally, such materials are less dense than metals and occupy a larger volume resulting in greater divergent forces.

[0010] Failure prone fragments exhibit three launch-induced failure modes, namely spall, lateral fracture, and explosive induced damage. Spall is manifested as one or more fractures perpendicular to the flight direction of the fragment. Spall is a consequence of excessive negative pressures within the material caused by the rarefaction of strong compressive waves communicated into the fragment during the detonation process. Lateral fracture is manifested as one or more failures parallel to the flight direction of the fragment. Lateral fractures are a consequence of excessive non-uniform velocity gradients along the fragment width caused by rarefactions within the detonation gases. Explosive induced damage is manifested as deformations and fractures along the fragment adjacent to the explosive charge. Explosive induced damage is a consequence of high-pressure, explosive products interacting with a low-strength fragment.

[0011] While metal-polymer materials in devices are disclosed in the related arts, the attenuation of launch-related failures by the invention described herein is neither described nor claimed in the related arts.

[0012] Kuhns et al. discloses one such related art device in U.S. Pat. No. 6,484,642 having a prescribed pattern of internal grooves or recesses partially traversing the thickness of a shell structure composed of steel thereby defining a plurality of inert fragments. An undefined energetic or reactive material occupies the recesses forming a continuous or nearly continuous web. An optional thin liner of metal, plastic, or ceramic is coated, adhered, or mechanically fastened over the reactive material to aid in fragment retention. The described confinement of reactive material serves no other purpose than to produce a high-pressure region within the recesses, via a compression of and/or reaction by the reactive material, so as to facilitate a controlled fragmentation of the shell. The rapid release of this high pressure within the reactive material, after fragmentation of the shell is completed, allows the uncontrolled particulation and dispersion of the same. In contrast, the present invention attenuates pressures within a fragment via a buffer-wrap system about the fragments so as to prevent mechanical failures and uncontrolled dispersion.

[0013] Hornig discloses an enhanced blast device in U.S. Pat. No. 5,852,256 comprised of a unitary casing of reactive material surrounding and contacting an explosive charge. Also described is a unitary liner of reactive material disposed between and contacting a hardened steel casing and an explosive charge. The steel casing facilitates penetration, protects the munition during penetration, and increases compression of the reactive material to enhance its dispersion and reactivity. In an alternate embodiment, larger fragments of reactive metal are dispersed within a polymer binder matrix therein having a finer reactive metal powder. The device disperses reactive material in a finely divided form over a relatively large space so as to enhance reactivity with the medium immediately surrounding the device. Dispersal is achieved by maximizing pressure and divergent forces within the reactive material. In contrast, the present invention attenuates high pressures within a fragment via a buffer-wrap system thereby preventing reaction during launch and minimizing divergent forces.

[0014] Cuadros discloses another device in U.S. Pat. No. 5,313,890 having a fabric liner woven from high-strength fibers located between and intimately contacting an explosive charge and preformed fragments, namely reactive-fluid filled fragments, as an improvement over ductile metal liners. The fabric liner softens the explosive launch of fragments via the controlled expansion and delayed venting of detonation products. Fragments are disposed between folds in a fabric liner that unfold as the explosive products expand thereby projecting fragments in an outward radial direction. Fragments are retained by an outer casing or enclosure, such as a tubular metal or plastic casing, or tape spirally wound around and contacting the fragments. In contrast, the present invention provides a coupled arrangement between buffer and wrap so as to attenuate the pressure state in a failure prone fragment. An inner buffer of sufficient density and thickness attenuates the shock communicated into fragments from the detonation event. An outer wrap communicates a shock into the fragment via impact between wrap and partially accelerated fragment further attenuating the negative phase of the incident shock.

[0015] What is required is an ordnance device capable of launching failure prone fragments in a coherent, controllable fashion. It is desired that the device attenuate the incident shock communicated into a fragment via a detonation event and/or attenuate the negative phase of the incident shock within a fragment and/or mitigate explosive induced damage thereon.

SUMMARY OF THE INVENTION

[0016] An object of the present invention is an ordnance device capable of launching low-strength, brittle fragments so as to avoid one or more damage modes inherent to such projectiles.

[0017] The present invention is comprised of an explosive charge, a buffer element, a plurality of preformed failure prone fragments, and a wrap element arranged in the order described. Formulations of failure prone materials are composed of, but not limited to, aluminum, magnesium, and zirconium powders within a matrix of one or more fluorine rich polymers. Likewise, failure prone materials may be comprised of brittle, chemically active or inert materials. Buffer elements are composed of a polymer or a metal or a composite of sufficient density and thickness to attenuate an incident shock communicated into the failure prone fragments after detonation of an explosive charge. Failure prone fragments are arranged in a continuous fashion along the buffer element. A wrap element having a first layer and a second layer is provided of sufficient density and thickness so as to communicate a shock into the preformed fragments to further attenuate the incident shock. The first layer is composed of a compressible material of lower density than the second layer. The second layer is composed of a polymer or a metal or a composite. Cylindrical and linear shaped embodiments are described and claimed. Confined and unconfined embodiments are also provided.

[0018] Alternate embodiments of the present invention include an optional second buffer element between explosive charge and buffer element. Additional embodiments include an optional thin polymer-based intermediate layer between fragments and wrap, as well as a thin polymer-based outer cover over the wrap element. In yet other embodiments, fragment length may vary with location and preformed inert fragments may be interspersed with failure prone fragments.

[0019] The present invention facilitates the exploitation of failure prone materials within ordnance systems.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which:

[0021] **FIG. 1** is a schematic diagram of an exemplary ordnance device having a single buffer element disposed between explosive charge and fragments with a layered outer wrap.

[0022] **FIG. 2** is a schematic diagram of an exemplary ordnance device having dually arranged buffer elements disposed between explosive charge and fragments with a layered outer wrap.

[0023] **FIG. 3** is a schematic diagram of a preferred embodiment having dually arranged buffer elements and intermediate layer disposed between fragments and layered outer wrap and an outer cover over the outer wrap.

[0024] **FIG. 4** is a perspective view of an exemplary embodiment of a cylindrically shaped device having fragments of fixed dimensions.

[0025] **FIG. 5** is a section view of a cylindrical shaped embodiment having variable length fragments with outer wrap not shown.

[0026] **FIG. 6** is a perspective view of an exemplary embodiment of a linearly shaped device having fragments of fixed dimensions.

[0027] **FIG. 7** is a section view of a linearly shaped embodiment showing arrangement of explosive, buffer, variable length fragments, and wrap within a confinement structure.

REFERENCE NUMERALS

[0028] **1** Ordnance device

[0029] **2** Explosive charge

[0030] **3** Buffer element

[0031] **4** Fragment

[0032] **5** Wrap element

[0033] **6** First Layer

[0034] **7** Second layer

[0035] **8** Second buffer element

[0036] **9** Intermediate layer

[0037] **10** Outer cover

[0038] **11** Cylindrically shaped device

[0039] **12** Length

[0040] **13** Width

[0041] 14 Thickness

[0042] 15 Diameter

[0043] 17 Linearly shaped device

[0044] 18 Confinement structure

[0045] 19 Explosive-buffer interface

[0046] 20 Central axis

[0047] 21 Lateral member.

DESCRIPTION OF THE INVENTION

[0048] Referring now to **FIG. 1**, an exemplary arrangement of the present invention, referred herein as an ordnance device **1**, is shown having an explosive charge **2** immediately adjacent to and contacting a buffer element **3** immediately adjacent to and contacting a plurality of fragments **4** immediately adjacent to and contacting a wrap element **5**. The term fragment **4** refers to preformed projectiles composed of a failure prone composition unless otherwise indicated. Components are assembled and mechanically fastened or adhered via methods and techniques understood in the art. For example, buffer element **3** and wrap element **5** may be planar disposed sheets that are conformally applied over explosive charge **2** and fragments **4**, respectively, thereby confining and supporting the fragments **4**. It is likewise possible of secure a cylindrically shaped buffer element **3** and wrap element **5** over explosive charge **2** and fragments **4**, respectively.

[0049] The explosive charge **2** projects fragments **4** to a desired velocity via the rapid release of energy during chemical decomposition of the explosive. Explosive compositions known within the art are applicable to the present invention. A variety of shapes are possible for the explosive charge **2** shown in **FIGS. 1-3**, including but not limited to rectangular, triangular, square, polygonal, hemispherical, elliptical and combinations thereof. Likewise, the linear explosive-buffer interface **19** shown in **FIG. 1** may be concave, convex or combinations thereof.

[0050] The buffer element **3** attenuates the shock communicated into the fragments **4** by the explosive charge **2**, as well as mitigates explosive induced damage on the fragments **4**. The buffer element **3** may be composed of a metal, non-limiting examples including steel, copper and aluminum, a polymer, non-limiting examples including polyethylene, plexiglas, and nylon, an elastomer, a non-limiting example being neoprene, or a composite, non-limiting examples including fiber-reinforced plastic, glass-reinforced plastic, and rigid woven fiber compositions, or laminates thereof.

[0051] Shock attenuation and damage mitigation are achieved via buffer element **3** design, namely thickness and density. For example, a buffer element **3** composed of copper having a thickness of 0.064-inches was sufficient to mitigate the deleterious effects on fragments **4** composed of PTFE-metal formulations by an explosive charge **2** having a diameter **15** of 4.85-inches.

[0052] Fragments **4** may be arranged in a column-like formation, as shown in **FIGS. 1-3**, between buffer element **3** and wrap element **5**. While a variety of fragment shapes are possible, it is preferred that fragments **4** align in a continuous fashion so as to minimize gaps or voids there between. Fragment size is performance and system dependent.

[0053] Fragments **4** may be composed of formulations of one or more fluoropolymers and one or more oxidation metals. Exemplary fluoropolymers include polychlorotrifluoroethylene (PCTFE), ethylene-tetrafluoroethylene (ETFE), fluorinated ethylene-propylene copolymer (FEP), polyvinylidene fluoride (PVDF), and perfluoroalkyl-tetrafluoroethylene copolymer (PFA), homopolymers and copolymers of fluorocarbon resins having analogs of ethylene such as polytetrafluoroethylene (PTFE), polymers of chloro-trifluoroethylene, and fluorinated ethylene, and homopolymers and copolymers of fluoroelastomers such as polyfluorocilicones. Exemplary oxidation metals include aluminum, titanium, magnesium, and zirconium. Solid compositions of the above may be manufactured by the method described by Joshi in U.S. Pat. No. 6,547,993. It is likewise possible to have fragments **4** composed of a chemically active or inert powder, preferably a metal, within a brittle or weak matrix composed of a polymer or ductile metal.

[0054] The wrap element **5** is comprised of a first layer **6** and a second layer **7**. The first layer **6** is disposed between and contacting both fragments **4** and second layer **7** either mechanically attached or adhered thereon via methods understood in the art. The second layer **7** is preferably composed of a metal, non-limiting examples including steel, copper, and aluminum. However, alternate embodiments may be composed of a polymer, non-limiting examples including polyethylene and nylon, or a composite, non-limiting examples including fiber-reinforced plastic, glass-reinforced plastic, and rigid woven fiber compositions, or laminates thereof.

[0055] The wrap element **5** communicates a shock into the fragments **4** of sufficient magnitude to reduce the negative pressures therein. The first layer **6**, both compressible and less dense than the second layer **7**, allows the fragments **4** to accelerate prior to contacting the second layer **7**. The interaction between fragments **4** and second layer **7** communicates a second shock into each fragment **4**. The first layer **6** may be composed of a foam, non-limiting examples including open-cell and closed-cell polymers, a non-porous polymer, non-limiting examples including polyethyelene and plexiglass, or an elastomer, a non-limiting example being neoprene. Rigid yet compressible foams were preferred. For example, a wrap element **5** composed of a 0.187-inch thick expanded, closed-cell polyethyelene foam having a density of 4 pounds-per-cubic-foot and a 0.030-inch thick aluminum was sufficient to adequately shock a 1.2-inch thick PTFE-metal fragment launched from a cylindrically shaped explosive charge **2** having an approximate diameter **15** of 10-inches.

[0056] In some embodiments, it may be preferred to provide a second buffer element **8**. Referring now of **FIG. 2**, a second buffer element **8** is shown disposed between the explosive charge **2** and the buffer element **3**. The second buffer element **8** is preferred to be less dense than the buffer element **3** described above. For example, the second buffer element **8** may be a gas-filled cavity, one example being air, allowing the explosive charge **2** to expand prior to contact with the buffer element **3**. Alternately, the second buffer element **8** may be a compressible material as described above for the first layer **6**. In yet other embodiments, if may be preferred to provide a pair of dually arranged layers about the wrap element **5**. Referring now to **FIG. 3**, a thin intermediate layer **9**, preferably a polymer, is shown between and contacting fragments **4** and wrap element **5**. A thin outer cover **10**, preferably a polymer, is also shown contacting the wrap element **5** oppositely disposed from the intermediate layer **9**. Both intermediate layer **9** and outer cover **10** are mechanically fastened to, adhered to, or coated onto the wrap element **5** via methods understood in the art.

[**0057**] Referring now to **FIG. 4**, a cylindrically shaped device **11** is described having a cylinder-shaped explosive charge **2** surrounded by a plurality of layers about a central axis **20**. Material arrangements shown in **FIGS. 1-3** are equally appropriate. The explosive charge **2** may consist of an unconfined mass of either cast or pressed explosive material. Alternatively, the explosive charge **2** may be comprised of an explosive filled container as understood in the art. The cylindrically shaped device **11** is secured to an ordnance system via means understood in the art.

[**0058**] A variety of detonation schemes may be employed within the cylindrically shaped device **11** via methods and devices understood in the art. For example, one or more detonation points may be positioned along or within the explosive charge **2**. Alternatively, an initiation scheme forming a toroidal or planar detonation wave may be employed so as to minimize explosive loading onto the fragments **4**.

[**0059**] Referring again to **FIG. 4**, likewise dimensioned rectangular-shaped fragments **4** are shown of prescribed length **12**, width **13**, and thickness **14**. However, other shapes are equally applicable including but not limited to cubes, spheres, and solid polygons. When the explosive charge **2** is cylindrically shaped, it is desired to have a slight tapering of the width **13** along the thickness **14** of the fragment **4** so as to accommodate circumference differentials. Preformed or individual fragments **4** are arranged in a contacting fashion to form a desired geometric arrangement, as shown in **FIG. 4**.

[**0060**] Fragments **4** are dimensioned so as to deliver an optimal mass onto the target, to achieve a desired hit probability, and in some applications to minimize divergent forces along the fragments **4** during their acceleration by the explosive charge **2**. For example, a fragment **4** having an approximate length-to-width ratio of 1.84 and an approximate thickness-to-width ratio of 1.75 adequately balanced design considerations. Furthermore, a width-to-diameter ratio approximately equal to 0.07 minimized divergent forces.

[**0061**] Referring now to **FIG. 5** shows a sectioned cylindrically shaped device **11** having a plurality of fragments **4** with differing length **12**. In other embodiments, it may be desired to have fragments **4** of differing length **12** and/or width **13** and/or thickness **14**.

[**0062**] In yet other alternate embodiments, it may be desired to intersperse preformed fragments **4** composed of such inert materials as steel or tungsten with the present invention. For example, fragments **4** composed of inert materials may be aligned in row or column formation with fragments **4** composed of failure prone materials. It is also possible to position a single fragment **4** of inert material with fragments **4** composed of failure prone materials disposed thereabout in a repeating pattern.

[**0063**] Referring now to **FIG. 6**, an exemplary embodiment of a linearly shaped device **17** is shown having an optional confinement structure **18**. Explosive charge **2**, buffer element **3**, fragments **4**, and wrap element **5** are disposed within, mechanically fastened and/or adhered via techniques understood in the art, and thereby surrounded by the confinement structure **18**, as shown in **FIG. 7**.

[**0064**] A typical confinement structure **18** is a box-like device having several lateral members **21** formed, fastened, attached, or adhered as is understood in the art. Exemplary lateral members **21** are planar shaped elements composed of a metal, plastic, or composite. Fragments **4** are disposed within the confinement structure **18** so as to avoid their contact with lateral members **21** during explosive launch.

[**0065**] Detonation schemes, fragment **4** variations, and mixed fragment **4** arrangements as described above for **FIGS. 4-5** are equally applicable to the linearly shaped device **17**.

[**0066**] The description above indicates that a great degree of flexibility is offered in terms of the present invention. Although the present invention has been described in considerable detail with reference to certain preferred versions thereof, other versions are possible. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained herein.

1. An ordnance device comprising:

(a) an explosive charge;

(b) a fragment layer including a plurality of preformed failure prone fragments;

(c) a metal buffer element disposed between said explosive charge and said fragment layer, said metal buffer element configured to attenuate an incident shock communicated into said fragment layer after detonation of said explosive charge, said preformed failure prone fragments of said fragment layer being arranged in a continuous fashion along said buffer element; and

(d) a wrap element having a first layer and a second layer, said first layer disposed between said second layer and said fragment layer opposite of said buffer element, said first layer composed of a compressible material of lower density than said second layer, said second layer configured to communicate a shock into said fragment layer to further attenuate said incident shock.

2. The ordnance device of claim 1, wherein said fragment layer further comprises a plurality of preformed inert fragments interspersed with said preformed failure prone fragments.

3. The ordnance device of claim 1, wherein said ordnance device is cylindrically shaped.

4. The ordnance device of claim 3, wherein said fragment layer further comprises a plurality of preformed inert fragments interspersed with said preformed failure prone fragments.

5. The ordnance device of claim 1, further comprising:

(e) a second buffer element disposed between said buffer element and said explosive charge, said second buffer element compressible and less dense than said buffer element.

6. The ordnance device of claim 5, wherein said ordnance device is cylindrically shaped.

7. The ordnance device of claim 6, further comprising a plurality of preformed inert fragments interspersed with said preformed failure prone fragments.

8. The ordnance device of claim 5, further comprising:

(f) a polymer-based intermediate layer disposed between and contacting said preformed failure prone fragments and said wrap element; and

(g) a polymer-based outer cover disposed along and contacting said second layer opposite of said first layer.

9. The ordnance device of claim 8, wherein said ordnance device is cylindrically shaped.

10. The ordnance device of claim 9, further comprising a plurality of preformed inert fragments interspersed with said preformed failure prone fragments.

11. The ordnance device of claim 9, wherein said preformed failure prone fragments have a width-to-charge-diameter ratio of approximately 0.07.

12. The ordnance device of claim 9, wherein said preformed failure prone fragments have a location dependent dimensional variability.

13. The ordnance device of claim 1, wherein said ordnance device is linearly shaped.

14. The ordnance device of claim 13, further comprising a plurality of preformed inert fragments interspersed with said preformed failure prone fragments.

15. The ordnance device of claim 13, further comprising:

(e) a confinement structure, said explosive charge, said buffer element, said preformed failure prone fragments and said wrap element disposed within said confinement structure in referenced order so as to allow launch of said preformed failure prone fragments unimpeded by said confinement structure.

16. The ordnance device of claim 15, wherein said preformed failure prone fragments have a location dependent dimensional variability.

17. The ordnance device of claim 15, further comprising a plurality of preformed inert fragments interspersed with said preformed failure prone fragments.

18. A method for launching a preformed failure prone fragments comprising the steps of:

(a) attenuating a first shock along a first surface of said preformed failure prone fragments;

(b) communicating a second shock into a second surface along said preformed failure prone fragments; and

(c) coupling said first shock and said second shock so as to reduce pressure and stress within said preformed failure prone fragments thereby avoiding mechanical failure.

19. The ordnance device of claim 2 wherein said preformed failure prone fragments have a width-to-charge-diameter ratio of approximately 0.07.

20. The ordnance device of claim 3 wherein:

said metal buffer element comprises a copper buffer element having a thickness of at least 0.064 inches; and

said explosive charge has a diameter of at least 4.85 inches.

* * * * *