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(54) **KINETIC ENERGY ROD WARHEAD WITH SELF-ALIGNING PENETRATORS**

(76) Inventor: **Richard M. Lloyd**, Melrose, MA (US)

Correspondence Address:
Iandiorio & Teska
260 Bear Hill Road
Waltham, MA 02451-1018 (US)

and which is a continuation-in-part of application No. 10/938,355, filed on Sep. 10, 2004, which is a continuation-in-part of application No. 10/456,777, filed on Jun. 6, 2003, now Pat. No. 6,910,423, which is a continuation-in-part of application No. 09/938,022, filed on Aug. 23, 2001, now Pat. No. 6,598,534.

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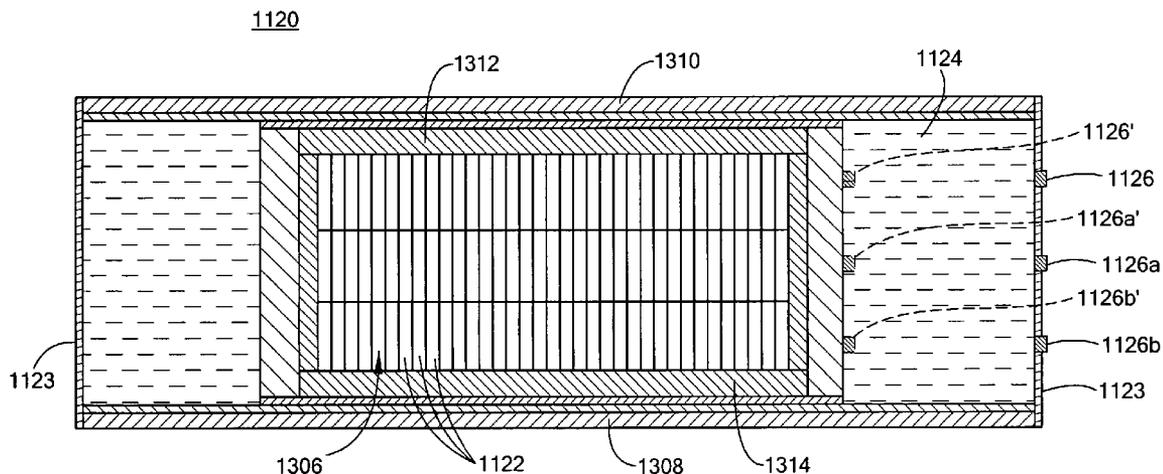
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Related U.S. Application Data

(63) Continuation-in-part of application No. 11/059,891, filed on Feb. 17, 2005.
Continuation-in-part of application No. 11/060,179, filed on Feb. 17, 2005, which is a continuation-in-part of application No. 10/924,104, filed on Aug. 23, 2004,

(57) **ABSTRACT**

A kinetic energy rod warhead with self-aligning penetrators includes a plurality of rods, an explosive for deploying the rods, and a detonator for detonating the explosive. A stabilizer is attached to all or selected rods for aligning said rods to strike a target at an optimal strike angle.



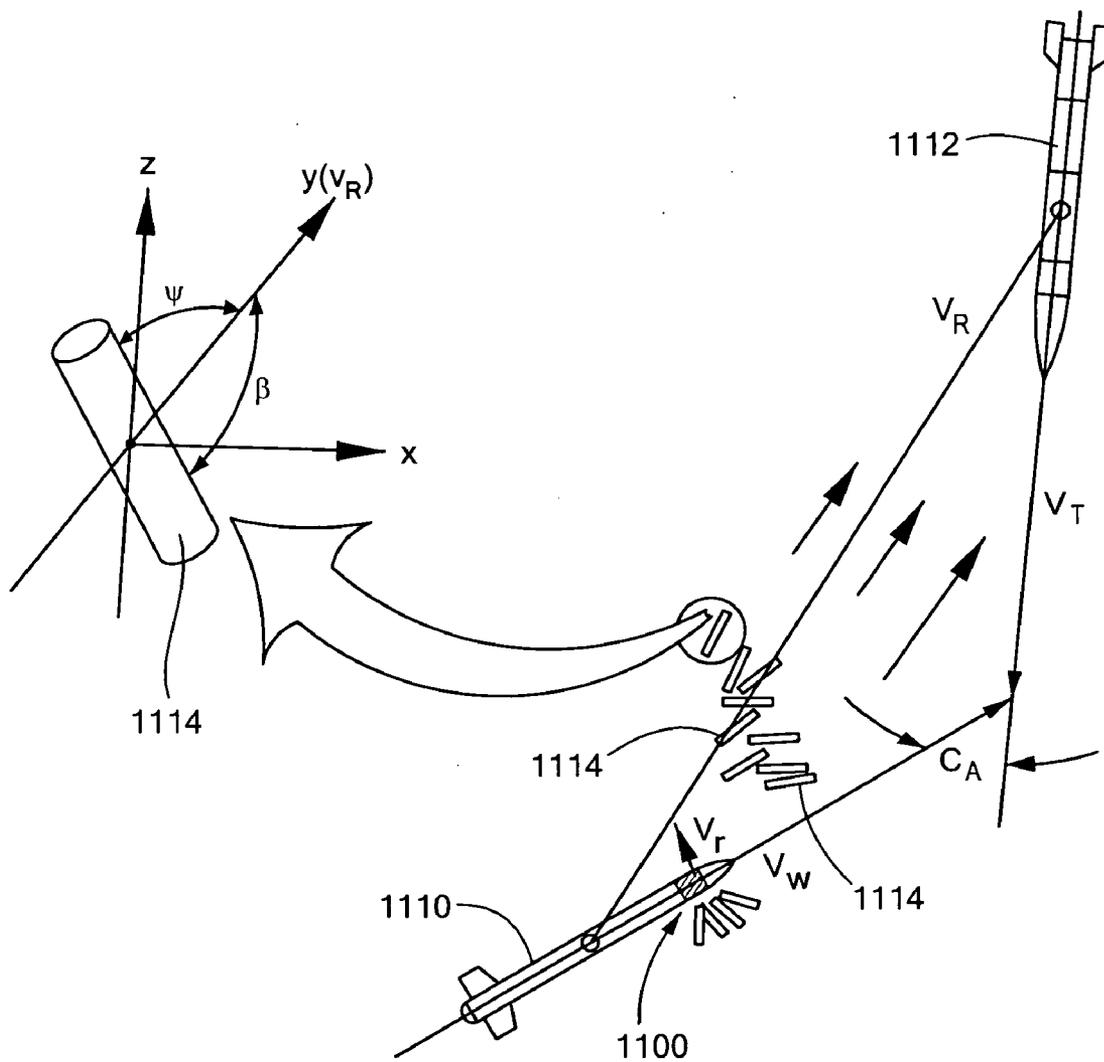


FIG. 1

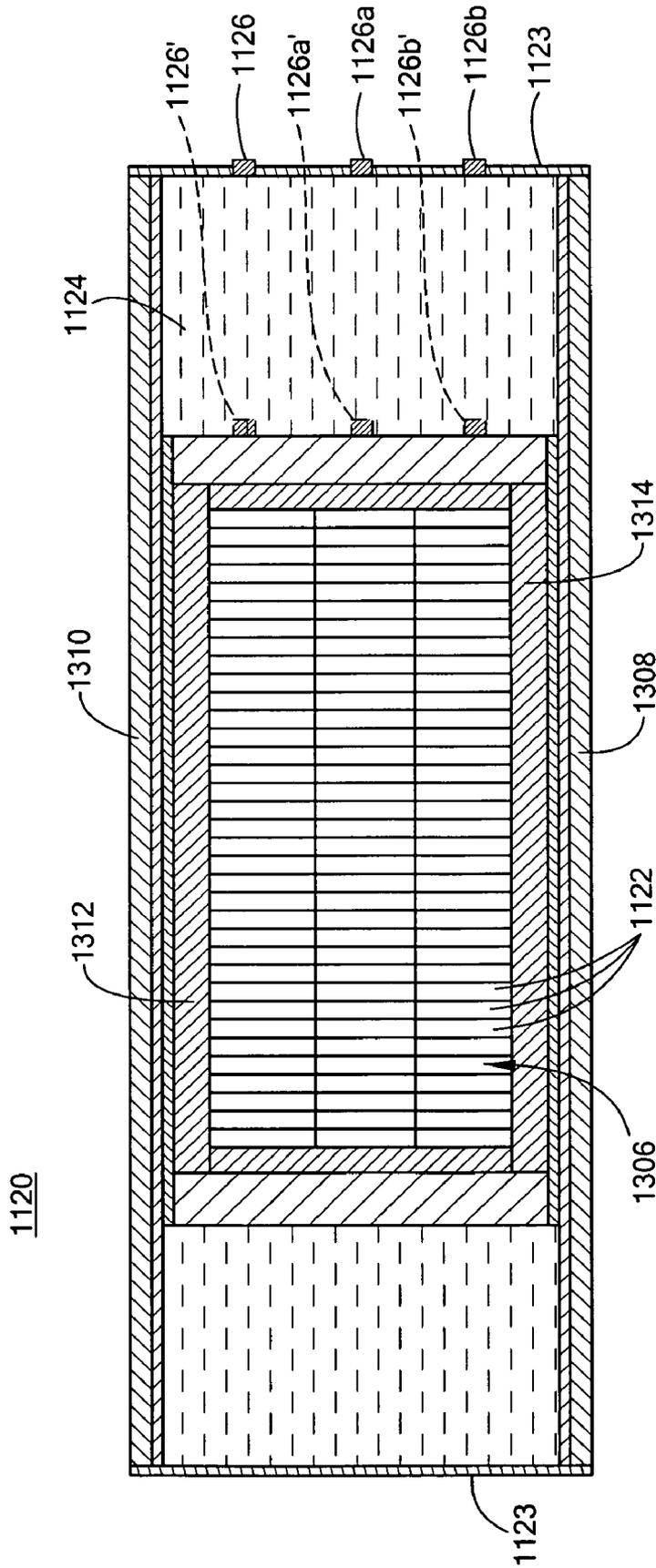


FIG. 2

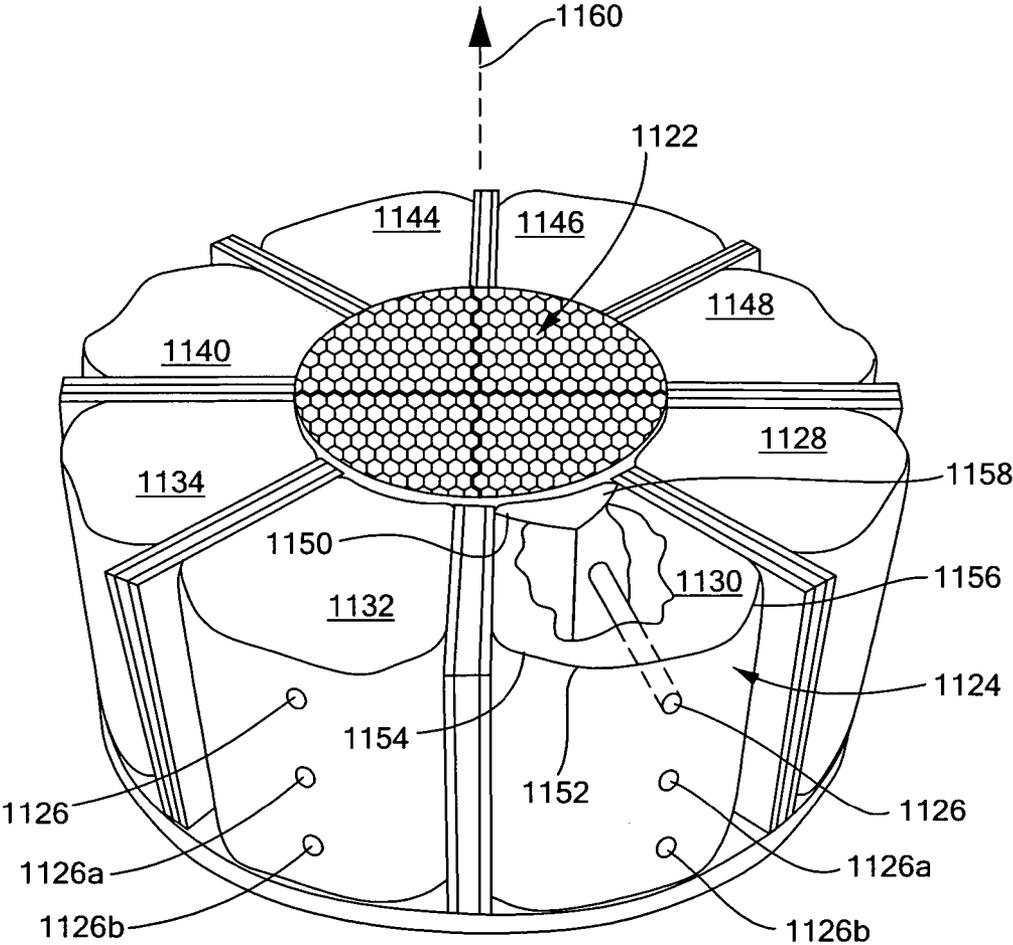


FIG. 3

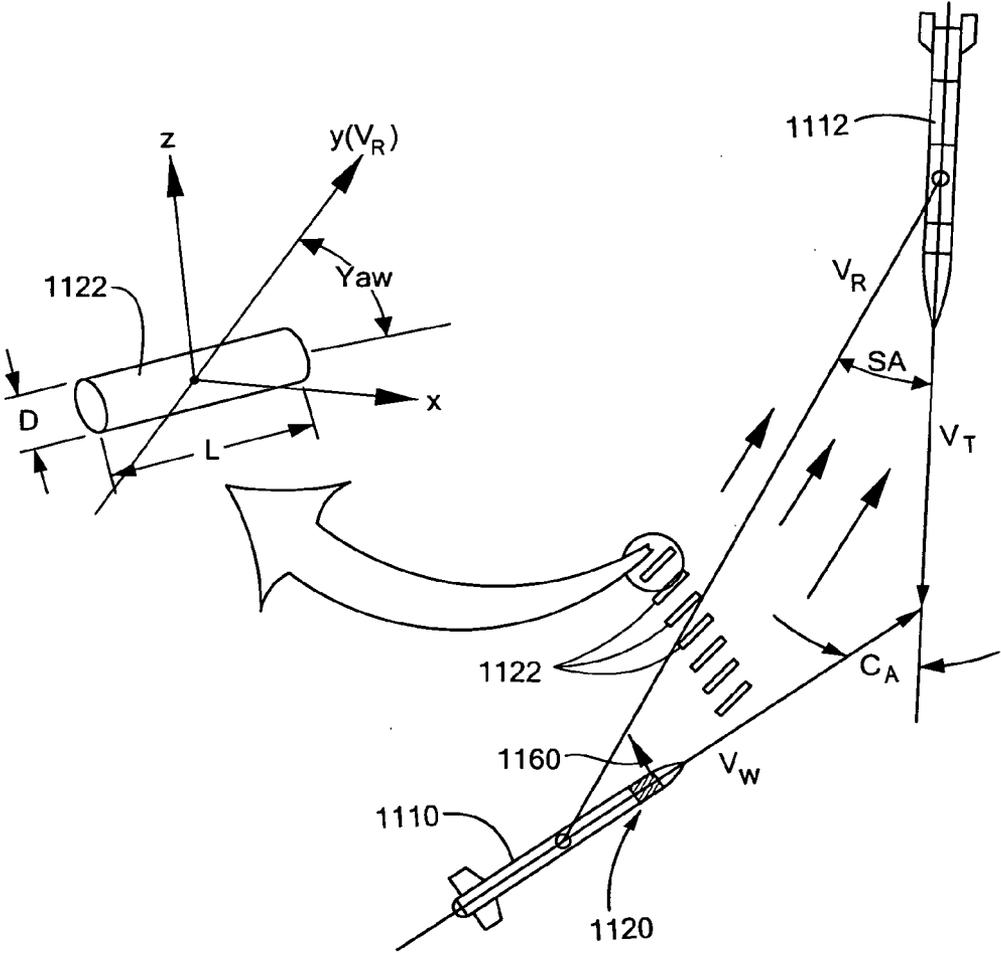


FIG. 4

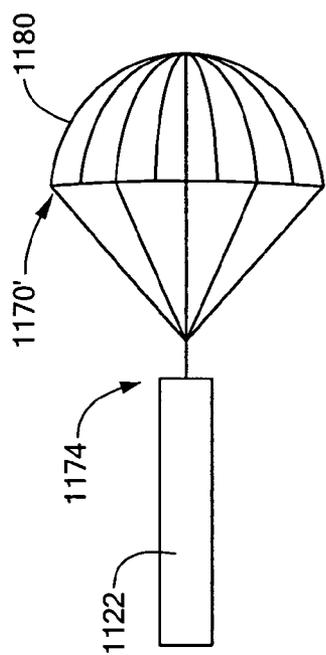


FIG. 6

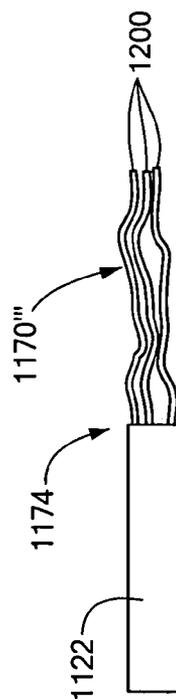


FIG. 8

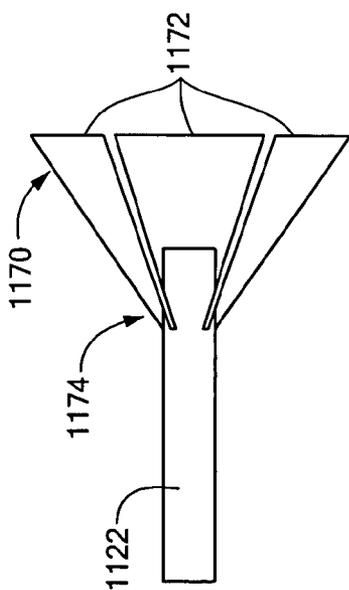


FIG. 5

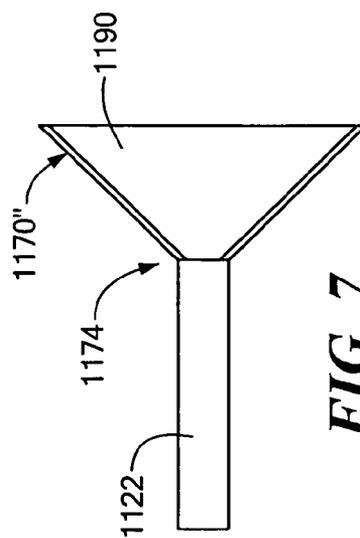


FIG. 7

KINETIC ENERGY ROD WARHEAD WITH SELF-ALIGNING PENETRATORS

RELATED APPLICATIONS

[0001] This application is a Continuation-in-Part of prior U.S. patent application Ser. No. 11/059,891 filed Feb. 17, 2005 and this application is a Continuation-in-Part of prior U.S. patent application Ser. No. 11/060,179 filed Feb. 17, 2005, and the latter applications are each a Continuation-in-Part application of prior U.S. patent application Ser. No. 10/924,104 filed Aug. 23, 2004 and a Continuation-in-Part application of prior U.S. patent application Ser. No. 10/938,355 filed Sep. 10, 2004, and each of these latter two applications are a Continuation-in-Part of prior U.S. patent application Ser. No. 10/456,777, filed Jun. 6, 2003 which is a Continuation-in-Part of prior U.S. patent application Ser. No. 09/938,022 filed Aug. 23, 2001, issued on Jul. 29, 2003 as U.S. Pat. No. 6,598,534B2. All of these patent applications and patents are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This subject invention relates to improved kinetic energy rod warhead rod penetrators.

BACKGROUND OF THE INVENTION

[0003] Destroying missiles, aircraft, re-entry vehicles and other targets falls into three primary classifications: "hit-to-kill" vehicles, blast fragmentation warheads, and kinetic energy rod warheads.

[0004] "Hit-to-kill" vehicles are typically launched into a position proximate a re-entry vehicle or other target via a missile such as the Patriot, Trident or MX missile. The kill vehicle is navigable and designed to strike the re-entry vehicle to render it inoperable. Countermeasures, however, can be used to avoid the "hit-to-kill" vehicle. Moreover, biological warfare bomblets and chemical warfare submunition payloads are carried by some "hit-to-kill" threats and one or more of these bomblets or chemical submunition payloads can survive and cause heavy casualties even if the "hit-to-kill" vehicle accurately strikes the target.

[0005] Blast fragmentation type warheads are designed to be carried by existing missiles. Blast fragmentation type warheads, unlike "hit-to-kill" vehicles, are not navigable. Instead, when the missile carrier reaches a position close to an enemy missile or other target, a pre-made band of metal on the warhead is detonated and the pieces of metal are accelerated with high velocity and strike the target. The fragments, however, are not always effective at destroying the target and, again, biological bomblets and/or chemical submunition payloads survive and cause heavy casualties.

[0006] The textbooks by the inventor hereof, R. Lloyd, "Conventional Warhead Systems Physics and Engineering Design," Progress in Astronautics and Aeronautics (AIAA) Book Series, Vol. 179, ISBN 1-56347-255-4, 1998, and "Physics of Direct Hit and Near Miss Warhead Technology", Volume 194, ISBN 1-56347-473-5, incorporated herein by this reference, provide additional details concerning "hit-to-kill" vehicles and blast fragmentation type warheads. Chapter 5 and Chapter 3 of these textbooks propose a kinetic energy rod warhead.

[0007] The two primary advantages of a kinetic energy rod warhead is that 1) it does not rely on precise navigation as

is the case with "hit-to-kill" vehicles and 2) it provides better penetration than blast fragmentation type warheads.

[0008] The primary components associated with a theoretical kinetic energy rod warhead are a projectile core or bay including a number of individual lengthy rod projectiles or penetrators, and an explosive charge. When the explosive charge is detonated, the rod projectiles are deployed. Typically, these components are within a hull or housing.

[0009] When choosing the size, weight and shape for the rod projectiles or penetrators, warhead designers must consider target vulnerability and miss distance. Factors such as whether the miss distance is large or small determine the spray density at impact, and factors such as the hardness or rigidity of the target determine depth penetration. Ideally, penetrators should be designed to neutralize all threats. Some threats require penetrators designed as spheres or a compact cube fragments. For other targets, however, if the penetrator has a length to diameter ratio of greater than two, deeper penetration into the target can be obtained if the penetrator center line is aligned along the relative velocity vector.

[0010] The projectiles, however, may tend to break and/or tumble in their deployment, and may approach the target at such a high oblique angle that they do not effectively penetrate the target. See "Aligned Rod Lethality Enhanced Concept for Kill Vehicles," R. Lloyd "Aligned Rod Lethality Enhancement Concept For Kill Vehicles" 10th AIAA/BMDD TECHNOLOGY CONF., Jul. 23-26, Williamsburg, Va., 2001 incorporated herein by this reference. The distribution of rod penetrators includes many rods that are not aligned with the relative velocity vector.

[0011] The inventor herein has improved the alignment of deployed rod projectiles or penetrators in various ways which are the subject of previously filed patent applications and patents. In one example, flux compression generators generate a magnetic field to align the projectiles. In another example, a plurality of detonators are spaced along the length of the explosive charge in the hull of the kinetic energy rod warhead to prevent sweeping shock waves at the interface between the projectile core and the explosive charge thus providing alignment. In a further example, a low density material (e.g. foam) body is disposed in the core of the kinetic energy rod warhead, and the body includes orifices which receive the projectiles. The low density material acts as a rigid support to hold the rods together after initial deployment. See e.g. U.S. Pat. No. 6,598,534 and U.S. Pat. Publ. No. 20040055500A1 each of which are incorporated herein by reference. Still another way of aligning rods developed by the inventor is in the context of a mine counter measure system. Each rod has a large length to diameter ratio and/or includes a stabilizer such as a plurality of fins or a flared distal end for aligning the rod about its velocity vector, thus providing better penetration of the surface above a mine. See U.S. patent application Ser. No. 10/685,242, which is incorporated herein by reference.

[0012] However, apart from the foregoing ways of aligning projectiles or rod penetrators, the nature of kinetic energy rod deployment is such that the penetrators still may not be properly aligned and thus may not provide optimal penetration of a target.

SUMMARY OF THE INVENTION

[0013] It is therefore an object of this invention to provide an improved kinetic energy rod warhead.

[0014] It is a further object of this invention to provide a higher lethality kinetic energy rod warhead.

[0015] It is a further object of this invention to provide rod penetrators which have a better chance of penetrating and destroying a target.

[0016] It is a further object of this invention to provide rod penetrators which self-align for better target penetration.

[0017] It is a further object of this invention to provide rod penetrators designed to strike a target at an optimal strike angle.

[0018] The subject invention results from the realization that a kinetic energy rod warhead with improved target penetration can be achieved with a stabilizer attached to all or selected rods to align the penetrators for optimal penetration.

[0019] The present invention thus provides a unique way to improve rod penetrator alignment for achieving optimal penetration of a target, and may be used exclusively, or in conjunction with any of the enumerated means of aligning projectiles disclosed in the applicant's patents or patent applications referenced above. Additionally, the kinetic energy rod warhead of the present invention may further include features for kinetic energy rod warheads disclosed in U.S. patent application Ser. Nos. 11/059,891 and 11/060,179, to which this application claims priority and which are incorporated herein by reference, and/or other features as desired for a particular application.

[0020] The subject invention, however, in other embodiments, need not achieve all these objectives and the claims hereof should not be limited to structures or methods capable of achieving these objectives.

[0021] This invention features a kinetic energy rod warhead with self-aligning penetrators including a plurality of rods, an explosive for deploying the rods, and a detonator for detonating the explosive. A stabilizer is attached to all or selected rods for aligning the rods to strike a target at an optimal strike angle. In one embodiment, the stabilizer is foldable for storage and expandable upon deployment. The rods may be lengthy cylindrical members made of tungsten. The stabilizer may include drag flaps attached at or proximate a distal end of the rod, and the drag flaps may be made of spring steel. The stabilizer may include a parachute attached at or proximate a distal end of the rod, or the stabilizer may include a flare attachment connected at or proximate a distal end of the rod. The stabilizer may include streamers attached at or proximate a distal end of rod, and the streamers may be made of plastic and may be several feet long.

[0022] This invention also features a kinetic energy rod warhead with self-aligning penetrators including a plurality of rods, an explosive for deploying the rods, a detonator for detonating the explosive, and a stabilizer foldable for storage and expandable upon deployment attached to all or selected rods for aligning the rods to strike a target at an optimal strike angle. The stabilizer may include drag flaps attached at or proximate a distal end of the rod, and the drag

flaps may be made of spring steel. The stabilizer may include a parachute attached at or proximate a distal end of the rod, or a flare attachment connected at or proximate a distal end of the rod. The stabilizer may include streamers attached at or proximate a distal end of rod, and the streamers may be made of plastic.

[0023] This invention further features a kinetic energy rod warhead with self-aligning penetrators including a plurality of rods, an explosive for deploying the rods, a detonator for detonating the explosive, and a spring steel drag flap stabilizer foldable for storage and expandable upon deployment attached to all or selected rods for aligning the rods to strike a target at an optimal strike angle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Other objects, features and advantages will occur to those skilled in the art from the following description of a preferred embodiment and the accompanying drawings, in which:

[0025] **FIG. 1** is a schematic view of ejected rods showing a distribution of rods with various yaw and pitch angle orientations;

[0026] **FIG. 2** is a schematic cross-sectional view of one example of a kinetic energy rod warhead in accordance with this invention;

[0027] **FIG. 3** is a schematic partial three-dimensional detailed view of the kinetic energy rod warhead of **FIG. 2**;

[0028] **FIG. 4** is a schematic view of ejected rods showing a distribution of rods with improved alignment in accordance with the present invention;

[0029] **FIG. 5** is a schematic view of a rod stabilizer including drag flaps in accordance with the present invention;

[0030] **FIG. 6** is a schematic view of a rod stabilizer including a parachute in accordance with the present invention;

[0031] **FIG. 7** is a schematic view of a rod stabilizer including a flare attachment in accordance with the present invention; and

[0032] **FIG. 8** is a schematic view of a rod stabilizer including streamers in accordance with the present invention.

DISCLOSURE OF THE PREFERRED EMBODIMENT

[0033] Aside from the preferred embodiment or embodiments disclosed below, this invention is capable of other embodiments and of being practiced or being carried out in various ways. Thus, it is to be understood that the invention is not limited in its application to the details of construction and the arrangements of components set forth in the following description or illustrated in the drawings. If only one embodiment is described herein, the claims hereof are not to be limited to that embodiment. Moreover, the claims hereof are not to be read restrictively unless there is clear and convincing evidence manifesting a certain exclusion, restriction, or disclaimer.

[0034] As discussed in the Background section above, upon deployment of the kinetic energy rod warhead **1100**, **FIG. 1**, which is typically added to missile or carrier **1110** to destroy target **1112**, projectiles **1114** may tend to break and/or tumble in their deployment and have many different yaw and pitch angles ω , β . Thus, penetrators **1114** may approach target **1112** at such an angle that they do not effectively penetrate target **1112**, which may be a re-entry vehicle or other type of threat. As shown in **FIG. 1**, a majority of penetrators **1114** are not aligned along their length with relative velocity vector V_R and are at angles that will be less than effective for penetrating target **1112**.

[0035] Kinetic energy rod warhead **1120** with self-aligning penetrators in accordance with this invention, **FIG. 2**, includes plurality of rods **1122**, explosive **1124** for deploying the rods, and detonator **1126** for detonating the explosive. The shape and configuration of kinetic energy rod warhead **1120** is not limited to any particular configuration and may include but is not limited to features disclosed in prior U.S. patent application Ser. No. 11/059,891. Although the exact configuration of the kinetic energy rod warhead may vary depending on a particular desired application or result to be achieved, in one embodiment kinetic rod warhead **1120** typically includes projectile core **1306**, thin plates **1308**, **1310** and thin aluminum absorbing layers **1312**, **1314** about projectiles **1122**, and includes, in one example, the plurality of rods **1122**. Preferably, explosive charge **1124**, **FIG. 3**, is divided into sections **1128**, **1130**, **1132** and **1134** disposed about the plurality of rods or projectiles **1122** within hull or housing **1123**. In one example, projectile rods **1122** are lengthy cylindrical members made of tungsten, although the rods are not necessarily limited to this shape or material, and may be of various shapes or materials depending on a desired application. There is at least one detonator **1126**, **1126a**, **1126b** for each section (shown for sections **1130** and **1132**) which may be placed as shown or at **1126'**, **1126a'**, **1126b'**, **FIG. 2**. Additional explosive sections **1142**, **1144**, **1146** and **1148**, **FIG. 2A** add versatility, depending on the desired application. In one variation, each explosive charge section is wedge shaped as shown with proximal surface **1150** of explosive charge section **1130** abutting the projectile core and distal surface **1152** which is tapered as shown at **1154** and **1156** to reduce weight. Optionally, the explosive sections may each include a wave shaper **1158** as shown for explosive section **1130**.

[0036] In this example, if explosive sections **1128**, **1130**, **1132** and **1134**, **FIG. 3** are detonated, the primary firing direction of the projectiles would be along vector **1160**, and thus rod projectiles **1122** would be deployed from kinetic energy rod warhead **1120** in the direction shown in **FIG. 4**.

[0037] To achieve alignment in accordance with this invention to strike target **1112**, **FIG. 4**, at an optimal strike angle, a stabilizer is attached to each of rods or a select portion of the total number of rods. In one preferred embodiment, the stabilizer is foldable for storage in the kinetic energy rod warhead and expandable upon deployment. The stabilizer is expanded or deployed about the axis of the rod projectile. When deployed, the stabilizer induces drag and helps to stabilize rod when it is ejected into the airstream. Consequently, the rod penetrators which include a stabilizer are better aligned with velocity vector V_R .

[0038] Rod stabilizer **1170**, **FIG. 5**, includes drag flaps **1172** attached at or proximal distal end **1174** of rod pen-

etrator **1122**. The strength and flexibility of material utilized for drag flap **1172** will depend upon the flap diameter, and the required flap diameter is a function of altitude at which kinetic energy rod warhead **1120**, **FIG. 4**, engages target **1112**, as well as air density. At higher altitudes the air density is lower and therefore a larger flap diameter would be required. At lower altitudes, there is a higher air density and thus the flap diameter would be smaller. In one preferred embodiment, drag flaps **1172**, **FIG. 5**, are made of light-weight spring steel, which may also facilitate folding until deployment. Once projectile rod **1122** is ejected, drag flap **1172** expands and provides proper aerodynamic stability.

[0039] Rod stabilizer **1170'**, **FIG. 6**, includes parachute **1180** to stabilize rod **1122**, where parachute **1180** is preferably attached at or proximate a distal end **1174** of rod **1122**. Use of parachute **1180** may depend on the altitude of deployment, and would preferably be used at higher altitudes where aerodynamic loads are less.

[0040] As shown in **FIG. 7**, rod stabilizer **1170''** includes flare attachment or nested rod **1190** connected at or proximate distal end **1174** of rod penetrator **1122**. Similar to parachute **1180**, flare attachment **1190** preferably would be utilized at higher deployment altitudes.

[0041] Rod stabilizer **1170'''**, **FIG. 8**, includes streamers **1200** for stabilizing rod **1122**. Streamers **1200** are preferably attached at or proximate distal end **1174** of projectile rod **1122** to move freely in the airstream. In one embodiment, streamers **1200** are made of plastic to be more easily folded or rolled up for storage prior to deployment. Preferably, streamers **1200** would be utilized at higher altitudes due to high dynamic forces at lower altitudes. Because the air density at higher altitudes is low, however, streamers **1200** utilized at such higher altitudes are preferably several feet long.

[0042] Thus, in accordance with the present invention, an improved, higher lethality kinetic energy rod warhead is effected with rod penetrators which self-align and have a better chance of penetrating and destroying a target by striking the target at an optimal strike angle.

[0043] Although specific features of the invention are shown in some drawings and not in others, this is for convenience only as each feature may be combined with any or all of the other features in accordance with the invention. The words "including", "comprising", "having", and "with" as used herein are to be interpreted broadly and comprehensively and are not limited to any physical interconnection. Moreover, any embodiments disclosed in the subject application are not to be taken as the only possible embodiments. Other embodiments will occur to those skilled in the art and are within the following claims.

[0044] In addition, any amendment presented during the prosecution of the patent application for this patent is not a disclaimer of any claim element presented in the application as filed: those skilled in the art cannot reasonably be expected to draft a claim that would literally encompass all possible equivalents, many equivalents will be unforeseeable at the time of the amendment and are beyond a fair interpretation of what is to be surrendered (if anything), the rationale underlying the amendment may bear no more than a tangential relation to many equivalents, and/or there are many other reasons the applicant can not be expected to describe certain insubstantial substitutes for any claim element amended.

What is claimed is:

1. A kinetic energy rod warhead with self-aligning penetrators, the warhead comprising:

a plurality of rods;

an explosive for deploying the rods;

a detonator for detonating the explosive; and

a stabilizer attached to all or selected rods for aligning said rods to strike a target at an optimal strike angle.

2. The kinetic energy rod warhead of claim 1 in which the stabilizer is foldable for storage.

3. The kinetic energy rod warhead of claim 2 in which the stabilizer is expandable upon deployment.

4. The kinetic energy rod warhead of claim 3 in which the stabilizer includes drag flaps attached at or proximate a distal end of the rod.

5. The kinetic energy rod warhead of claim 4 in which said drag flaps are made of spring steel.

6. The kinetic energy rod warhead of claim 3 in which the stabilizer includes a parachute attached at or proximate a distal end of the rod.

7. The kinetic energy rod warhead of claim 3 in which the stabilizer includes a flare attachment connected at or proximate a distal end of the rod.

8. The kinetic energy rod warhead of claim 3 in which the stabilizer includes streamers attached at or proximate a distal end of rod.

9. The kinetic energy rod warhead of claim 8 in which the streamers are made of plastic.

10. The kinetic energy rod warhead of claim 9 in which the streamers are several feet long.

11. The kinetic energy rod warhead of claim 1 in which the rods are lengthy cylindrical members.

12. The kinetic energy rod warhead of claim 1 in which the rods are made of tungsten.

13. A kinetic energy rod warhead with self-aligning penetrators, the warhead comprising:

a plurality of rods;

an explosive for deploying the rods;

a detonator for detonating the explosive; and

a stabilizer foldable for storage and expandable upon deployment attached to all or selected rods for aligning said rods to strike a target at an optimal strike angle.

14. The kinetic energy rod warhead of claim 13 in which the stabilizer includes drag flaps attached at or proximate a distal end of the rod.

15. The kinetic energy rod warhead of claim 14 in which said drag flaps are made of spring steel.

16. The kinetic energy rod warhead of claim 13 in which the stabilizer includes a parachute attached at or proximate a distal end of the rod.

17. The kinetic energy rod warhead of claim 13 in which the stabilizer includes a flare attachment connected at or proximate a distal end of the rod.

18. The kinetic energy rod warhead of claim 13 in which the stabilizer includes streamers attached at or proximate a distal end of rod.

19. The kinetic energy rod warhead of claim 18 in which the streamers are made of plastic.

20. A kinetic energy rod warhead with self-aligning penetrators, the warhead comprising:

a plurality of rods;

an explosive for deploying the rods;

a detonator for detonating the explosive; and

a spring steel drag flap stabilizer foldable for storage and expandable upon deployment attached to all or selected rods for aligning said rods to strike a target at an optimal strike angle.

* * * * *