

☐ Description : paged to ☐ Claim(s) : paged to ☐ Drawing(s) : paged to ☐ Abstract : paged to DATE OF RECEIPT ASYMMETRIC PENETRATION WARHEAD	PCT/IL96/00086
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FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to projectiles and missiles and, more particularly, to roll-stabilized guided missiles or "smart bombs" designed to reach and penetrate specific hardened targets.

For ease of presentation, the present invention is described herein in terms of a guided missile, it being understood that the present invention is of far broader applicability.

A typical guided missile is commonly made up of a number of 10 sections, which are housed in, or connected to a generally cylindrical housing of varying radius in the longitudinal direction.

At the front of the missile is the guidance section which typically includes one or more sensors, such as a Forward Looking Infrared (FLIR) or video camera, and the various electronic systems which control the 15 sensors, analyze and interpret the signals received by the sensors, and control the flight control system which determines the trajectory and the roll position of the missile. The guidance section may also include means for receiving signals from outside of the missile and may also includes means for transmitting signals from the missile.

20 Behind the guidance section is the warhead which is typically a hollow cylindrically shaped casing, typically made of a high strength steel.



The function of a penetration warhead is to penetrate a hardened target and place the explosive charge in the appropriate position, i.e., inside the target, at the moment of explosion, thereby maximizing the effect of the explosion on the target. Inside the hollow casing is placed the explosive
5 and the rear end of the warhead lies the ignition fuse which is designed to be set off at the proper moment, typically, at some pre-determined time after the warhead encounters the target. The warhead is typically made of three sections: (1) a front section, or nose, which is usually in the shape of an ogive or cone; (2) the main section which includes the explosive
10 charge and is usually cylindrical; and (3) the aft section which seals the explosive charge within the casing and holds the fuse.

Behind the warhead typically lies the engine which provides thrust to the missile.

Housed in and connected to the housing at the rear of the missile,
15 and in some cases also in other locations along the missile housing, is the flight control section, including fins and foils, which are used to adjust and stabilize the trajectory of the missile during its flight to the target and to prevent the missile from rolling during flight.

For maximum penetration of the hardened target it is desirable to
20 have the missile impact the target directly, i.e., at a 90° to the target surface. In most cases, however, the angle of impact is different, sometimes significantly, from the optimal 90° .

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For example, a significant fraction of hardened targets, such as command bunkers, and the like, are built into the ground and have an outer wall which is substantially horizontal. A typical guided missile would typically impact the outer wall at an angle which, in many cases, 5 may be in the range of from about 45° to about 65° , substantially different from the optimal angle of 90° . The deviation of the impact from the perpendicular greatly reduces the penetration depth of the warhead into the target and significantly decreases the effectiveness of the explosion.

There is thus a widely recognized need for, and it would be highly 10 advantageous to have, a warhead which is configured so as to improve its penetration when impacting the target at an angle which deviates from the perpendicular.

SUMMARY OF THE INVENTION

According to the present invention there is provided a penetration 15 warhead for use in a position-controlled roll-stabilized missile, the warhead having a main axis, the warhead comprising a nose section which is asymmetric with respect to the main axis of the warhead.

Also according to the present invention, there is provided a roll-stabilized position-controlled missile, comprising a warhead having a nose 20 section, the warhead being characterized in that the nose section is asymmetric with respect to the axis of the warhead.

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According to further features in preferred embodiments of the invention described below, the nose section includes a portion which projects forward such that during impact of the missile with a target, the portion of the nose is the first to make contact with the target.

5 The present invention successfully addresses the shortcomings of the presently known configurations by providing a penetration warhead or projectile which is shaped to include a nose section which is asymmetric with respect to its longitudinal axis. The warhead is intended for use in a roll-stabilized, position-controlled, guided missile or projectile designed
10 to penetrate a hardened concrete target or other highly resistant targets. Roll-stabilization relates to the keeping of the angular position of the missile about its axis roughly constant. Position control relates to ensuring that the missile is oriented so that the top portion is pointing up while the bottom portion is pointing down, i.e., to prevent the missile from flying
15 with the wrong roll angle.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 shows an illustrative guided missile according to the present
20 invention as it appears just prior to impact with a target;

FIG. 2 shows a warhead with a ogival nose;



FIG. 3 shows a warhead with an conical nose;

FIG. 4 indicates the path of a projectile impacting a target at a very low angle resulting in a ricochet;

FIG. 5 indicates the path of a projectile impacting a target at a larger angle than in Figure 4 resulting in a J-shaped trajectory;

FIG. 6 indicates the path of a projectile impacting a target at a larger angle than in Figure 5 resulting in an attenuated J-shaped trajectory;

FIG. 7 indicates the path of a projectile impacting a target at a 90° angle;

10 FIG. 8 schematically depicts the forces experienced by a conventional warhead upon impact;

FIG. 9 schematically depicts the forces experienced by a warhead according to the present invention upon impact;

FIG. 10 shows a comparison between the paths taken by a conventional warhead and a warhead according to the present invention following impact with a target at an angle;

FIG. 11 shows a side view of one possible nose design of a warhead according to the present invention;

FIG. 12 is a front view of the nose of Figure 11;

20 FIG. 13 shows a side view of a second possible nose design of a warhead according to the present invention;

FIG. 14 is a front view of the nose of Figure 13;

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FIG. 15 shows a third possible nose design of a warhead according to the present invention;

FIG. 16 is a top view of the nose of Figure 15;

FIG. 17 shows a side view of a fourth possible nose design of a warhead according to the present invention;

FIG. 18 is a top view of the nose of Figure 17;

FIG. 19 shows a side view of a fifth possible nose design of a warhead according to the present invention;

FIG. 20 is a front view of the nose of Figure 19;

FIG. 21 shows a side view of a sixth possible nose design of a warhead according to the present invention;

FIG. 22 is a front view of the nose of Figure 21.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of a penetration warhead assembled in a roll-stabilized or non-rolling guided missile or smart bomb (herein referred to collectively or singularly as "missile") body having a construction which significantly improves the penetration of the warhead into a target which is impacted at an angle which differs from the perpendicular.

The principles and operation of a warhead or missile according to the present invention may be better understood with reference to the drawings and the accompanying description. Shown in Figure 1, is a



schematic side cross-sectional view of a missile 10 which includes a guidance section 12, a warhead 14 (which is described in greater detail below), with an explosive charge 15, an engine section 16 and a flight control section 18 and tail fins 20. Missile 10 is shown just prior to impact with a target 22, at a certain angle, α , between the plane of the target and the main (longitudinal) axis of missile 10.

Presently, various warheads, bombs and projectiles are used for penetrating armored vehicles, such as tanks and thick concrete or similar other hard or hardened targets, typically made of concrete and further protected by layers of rock, soil and/or steel.

Presently available warheads are symmetrical so that the performance of the missile is independent of its roll angle at the moment of impact between the missile and the target. The symmetry of the warhead is critical in missiles, bombs, and the like, which roll during flight so that it is not possible to predict the roll angle of the missile at the instant of impact.

Typically, the nose of a conventional warhead has either an ogival or a conical front section (Figures 2 and 3, respectively), both configurations being completely symmetrical with respect to the main axis of the warhead.

The purpose of a penetration warhead is to penetrate as deeply as possible into the target in order to place the explosives in the targeted



space, or as close to it as possible. The extent of penetration of the warhead is greatly affected by the angle of impact, i.e., the angle between the main axis of the missile or warhead and the plane of the target.

Most warheads strike their target at angles which are substantially in the range of from about 45° to about 65° . At sufficiently small angles there is a greater chance of a ricochet, i.e., the warhead is likely to fail to penetrate the target and to bounce off the target (Figure 4).

At an impact angle of greater than about 45° , the warhead penetrates the target but tends to form a J-shaped path (Figures 5). The diversion of the warhead from a straight line path is caused by an imbalance of forces on the nose of the warhead, as shown schematically in Figure 8 which induces a moment tending to rotate the warhead about its center of gravity in a direction away from the target. In some cases the warhead comes to a stop with its nose pointing somewhat away from the target (Figure 2). The J-shaped path implies a decreased penetration of the warhead into the target.

At somewhat larger impact angles, milder J-shaped paths are encountered (Figure 6).

Finally, when the missile impacts the target perpendicularly, i.e., at 90° , the warhead moves directly into the target and maximum penetration depth is achieved (Figure 7). In some cases the differences in penetration achieved with a head-on impact (Figure 7) and angled impacts



(Figures 5 and 6) could mean the difference between delivery of the explosive charges directly into, or in close proximity to, the intended area, with a resultant highly effective explosion, and allowing the explosives to detonate in a location where little or no real damage is done to the intended target.

The present invention relates to a kinetic energy penetrating warhead which is designed to at least partly mitigate the negative effects of an angled impact of a hardened target. A warhead according to the present invention includes, in sharp contrast with known warheads, a front section, or nose, which is asymmetric with respect to the main axis of the warhead. A warhead according to the present invention is intended for use with guided missiles, projectile or smart bombs which do not roll, or are roll-stabilized, position-controlled and which are designed to penetrate hard and high value targets. In such systems, the missile or bomb has defined up and down portions and impact takes place substantially with the lower portion of the system (Figure 9).

As is shown schematically in Figure 9, the asymmetric configuration of the warhead makes it possible for the warhead to dig into the target by allowing the target counter forces to act on the warhead so as to counter and correct the tendency of the warhead to take a J-shaped path, as shown in Figures 8, 5 and 6. The forces acting on the nose of the warhead thus tend to create a moment about the warhead's center of



gravity which tends to direct the penetrating warhead in a direction which is substantially toward the perpendicular, thereby increasing the warhead's penetration depth.

The difference in path taken by two warheads, one symmetrical and 5 the other asymmetrical, is illustrated schematically in Figure 10. As can be seen, the symmetrical warhead is diverted from its intended direction while the path of an asymmetric warhead according to the present invention is actually corrected so as to approach the perpendicular. The resultant deeper penetration, and resultant enhanced explosion 10 effectiveness, can be seen in Figure 10.

Various and sundry asymmetric nose sections may be envisioned. All of these are intended to be included within the scope of the present invention. Illustrative of some of the various possibilities are the configurations shown in Figures 11 to 22. The precise choice of nose 15 design and degree of asymmetry will depend on the parameters of intended applications, perhaps including, but not limited to, the expected nature of the target, the type of explosives used and the expected angle of impact.

Shown in Figures 11 and 12 are a side and a front view of a nose design which includes a planar surface. The planar surface takes on the 20 shape of an ellipse.

Another possible configuration is shown in Figures 13 and 14. Here, the nose section is in the shape of an oblique cone, i.e., a cone



which is asymmetric with respect to its base or, more importantly with respect to the main axis of the warhead whereas the cone tip can be at any designed distance from the warhead main axis.

Shown in Figures 15 and 16 is a nose section which is
5 asymmetrically concave while the nose section in the embodiments of Figures 17 and 18 are asymmetrically convex. Finally, shown in Figures 19 and 20 and in Figures 21 and 22 are two more configurations which are asymmetrically concave and convex.

While the invention has been described with respect to a limited
10 number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.

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WHAT IS CLAIMED IS:



1. A penetration warhead for use in a position-controlled roll-stabilized missile, the warhead having a main axis, the warhead comprising a nose section which is asymmetric with respect to said main axis of the warhead.
2. The warhead of claim 1, wherein said nose section includes a planar configuration at its anterior end.
3. The warhead of claim 1, wherein said nose section includes an oblique conical configuration at its anterior end.
4. The warhead of claim 1, wherein said nose section includes a convex configuration at its anterior end.
5. The warhead of claim 1, wherein said nose section includes a concave configuration at its anterior end.
6. A roll-stabilized position-controlled missile, comprising a warhead having a nose section, said warhead being characterized in that said nose section is asymmetric with respect to an axis of the warhead.



7. The missile of claim 6, wherein said nose section includes a planar configuration at its anterior end.

8. The missile of claim 6, wherein said nose section includes an oblique conical configuration at its anterior end.

9. The missile of claim 6, wherein said nose section includes a convex configuration at its anterior end.

10. The missile of claim 6, wherein said nose section includes a concave configuration at its anterior end.

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