

(19)



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(11)

EP 0 845 098 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

21.03.2001 Bulletin 2001/12

(21) Application number: **96927859.7**

(22) Date of filing: **16.08.1996**

(51) Int Cl.7: **F42B 12/06**, F42B 30/08

(86) International application number:
PCT/IL96/00086

(87) International publication number:
WO 97/07379 (27.02.1997 Gazette 1997/10)

(54) **ASYMMETRIC PENETRATION WARHEAD**

ASYMMETRISCHES PENETRATORGESCHOSS

TETE EXPLOSIVE DE PENETRATION ASYMETRIQUE

(84) Designated Contracting States:
AT BE CH DK ES GR IT LI NL PT SE

(30) Priority: **17.08.1995 IL 11497395**

(43) Date of publication of application:
03.06.1998 Bulletin 1998/23

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US-A- 3 401 637	US-A- 3 869 101
US-A- 3 949 677	US-A- 4 085 678
US-A- 4 228 973	US-A- 4 389 028
US-A- 4 637 313	US-A- 4 998 994

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Description

FIELD AND BACKGROUND OF THE INVENTION

[0001] The present invention relates to missiles or projectiles designed to reach and penetrate specific hardened targets. Such a projectile is described in US-A-4 085 678. This document is considered to be the closest prior art.

[0002] 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.

[0003] A typical guided missile is commonly made up of a number of sections, which are housed in, or connected to a generally cylindrical housing of varying radius in the longitudinal direction.

[0004] 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 sensors, analyze and interpret the signals received by the sensors, and control the flight control system which positively 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 include means for transmitting signals from the missile.

[0005] 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 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 charge and is usually cylindrical; and (3) the aft section which seals the explosive charge within the casing and holds the fuse.

[0006] Behind the warhead typically lies the engine which provides thrust to the missile.

[0007] Housed in and connected to the housing at the rear of the missile, 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.

[0008] For maximum penetration of the hardened target it is desirable to 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 sig-

nificantly, from the optimal 90°.

[0009] 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, 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.

[0010] DE-A-1 428 690 discloses a projectile featuring an asymmetric tip, such that when the projectile hits a target it creates forces which hasten the deviation of the projectile. The asymmetric tip of the projectile accelerates the inclination of the projectile upon impacting a target. A similar projectile is disclosed in US-A-3 282 214. An asymmetric tip of the projectile causes the projectile to ultimately travel in a broadside position that is transverse with respect to the travelled path of the projectile prior to impacting the target. US-A-3 949 677 discloses a projectile with an asymmetrical tip shaped to increase the rate of spin of the projectile during its penetration into a target.

[0011] There is thus a widely recognized need for, and it would be highly 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

[0012] According to the present invention there is provided a penetration warhead in combination with a missile having defined up and down portions, said missile being position-controlled to ensure that the missile flies with the up portion oriented up and the down portion facing down and said missile being roll-stabilised to keep the angular position of the missile about its axis roughly constant, said warhead having a main axis and comprising a nose section which is asymmetric with respect to said main axis of the warhead, said asymmetry being selected so that upon impacting and penetrating a target, at an angle which deviates from a perpendicular to a surface of said target, the forces acting on said nose section by said target, create a moment about a warhead's center of gravity which directs the penetration warhead in a direction which is substantially toward the perpendicular to the surface of the target, thereby increasing the warhead's penetration depth into the target.

[0013] 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 mounted in a roll-stabilized, position-controlled, guided

missile or projectile designed 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 with the wrong roll angle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] 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 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;

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. 10A 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. 10B shows a comparison among the paths taken by a bomb as disclosed in GB 539699, a warhead according to the present invention and a conventional warhead 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;

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;

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; and

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

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] The present invention is of a penetration warhead assembled in a roll-stabilized guided missile, smart bomb or warhead 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 invention is described in claim 1. Dependent claims 2-5 describe preferred embodiments.

[0016] 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**.

[0017] 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.

[0018] 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.

[0019] 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.

[0020] 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.

[0021] 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).

[0022] 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, **M**, 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. The J-shaped path implies a decreased penetration of the warhead into the target.

[0023] At somewhat larger impact angles, milder J-shaped paths are encountered (Figure 6).

[0024] 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.

[0025] 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.

[0026] 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, the asymmetry is selected such that the forces acting on the nose of the warhead 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.

[0027] A warhead according to the present invention is intended for use with guided missiles, projectile of 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.

[0028] 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, **M**, about the warhead's center of grav-

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

[0029] The difference in path taken by two warheads, one symmetrical and the other asymmetrical as described, is illustrated schematically in Figure 10A. 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 effectiveness, can be seen in Figure 10A.

[0030] Asymmetry of various projectiles has been a subject of interest for a long time. U.S. Pat. No. 603,466 to Hammer discloses projectiles with an asymmetric nose section and flanges to control the traveling direction of the projectiles (i.e., before impacting a target). The projectiles described by Hammer are not roll stabilized and/or position controlled. WO 82/03453 (PCT/AU82/00044) to Thomson disclose a missile having a directional control device which affects the symmetry of its nose section during traveling (i.e., again, before impacting a target). Thus, both Hammer and Thomson disclose projectiles having an oblique conical configuration at their anterior end, which configuration affects their aerodynamic progress or flight through air (or hydrodynamic progress through water), however, these configurations do not affect their penetration capabilities into a target in a manner that will create a moment about the center of gravity which directs the projectile in a direction which is substantially toward the perpendicular during penetration. In other words, these patents provide designs for controlling a projectile during its flight to the target, which designs are not at all applicable for controlling the projectile's behavior after impact (i.e., during penetration).

[0031] Furthermore, the Hammer patent was published at 1898. Therefore, Hammer could not have possibly describe an active roll-stabilized position-controlled missile, since such projectiles were developed about 40 years later. The first roll-stabilized position controlled missile was introduced by the Germans during WW2. These missiles are known as V1 and V2.

[0032] In fact, Hammer describes a bullet which is fired from a firearm. There is a sharp distinction between a bullet and warhead of a missile, which, as opposed to a bullet, includes explosives. Webster's dictionary defines a warhead as the forward section of a missile, bomb, torpedo, or the like, containing the explosive or payload.

[0033] Further concerning the invention by Thomson, note that the present invention is not directed toward a missile having an oblique conical configuration at its anterior end. Flight or path control according to the missile of the present invention is effected via, for example, tail fins 20 (see Figure 1).

[0034] Other projectiles having asymmetric nose sections are disclosed in U.S. Pat. Nos. 4,998,994 to

Schmidt et al., 4,389,028 to Kalivretenos et al., 3,869,101 to Schnabele et al., 3,401,637 to Briscoe, and in FR 2673277A to Roland.

[0035] U.S. Pat. No. 4,085,678 to Heincker discloses a projectile equipped with a warhead having a forward section and an aft section. The forward section has an asymmetric rear end, whereas the aft section has an asymmetric front end, such that these rear and front ends match one another. The forward section is used to penetrate a target, whereas the aft section includes the explosives and is intended to follow the forward section into the target.

[0036] Thus, the warhead taught by Heincker does not have a nose section which is asymmetric with respect to the main axis of the warhead. In other words, the nose section of the warhead taught by Heincker is symmetric.

[0037] This is clearly evident from the Figures accompanying Heincker's disclosure.

[0038] Therefore, such a warhead would suffer all the limitations of a conventional symmetric warhead, which limitations are solved by a nose section which is asymmetric with respect to the main axis of the warhead.

[0039] Thus, Heincker teaches an aft section of a warhead which has an asymmetric front, however, that front is not intended for penetrating the target, as specifically explained on column 3, lines 41-53, of the Heincker patent. On the contrary, as therein specifically explained, it is the front of the forward section of the warhead which is intended to penetrate the target, wherein the aft section merely follows the forward section, which is symmetric.

[0040] In addition Heincker's missile is not a position-controlled roll-stabilized missile, and therefore the roll position of the Heincker's missile upon impact is a matter of statistics.

[0041] GB 539699 to Kent discloses an aerial bomb with a nose section equipped with a detachable part, such that, upon impacting a water body, the detachable part disintegrates and renders the nose section asymmetric. The asymmetry in this case is selected such that following impact (i.e., in water) the forces acting on the nose section 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 horizontal (see Figure 8 therein).

[0042] A distinctive difference in the constructions and therefore the behavior following impact of the bomb described by Kent, the warhead according to the present invention and a conventional symmetric warhead is emphasized in Figure 10B.

[0043] Considering an impact angle α (e.g., 45-65 °) in a horizontal target, the bomb of Kent, as indicated by **100**, progresses in a path which becomes closer to the horizontal, whereas the warhead according to the present invention, as indicated by **102**, progresses in a path which becomes closer to the vertical. In other words, the bomb of Kent progresses away from the per-

pendicular, whereas the warhead according to the present invention progresses closer to the perpendicular. A symmetric warhead, as indicated by **104**, would take an intermediate path (see also Figure 10A).

[0044] 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 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.

[0045] 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 shape of an ellipse.

[0046] 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.

[0047] Shown in Figures 15 and 16 is a nose section which is 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.

Claims

1. A penetration warhead (14) in combination with a missile (10) having defined up and down portions, said missile (10) being position-controlled to ensure that the missile flies with the up portion oriented up and the down portion facing down and said missile (10) being roll-stabilised to keep the angular position of the missile about its axis roughly constant, said warhead (14) having a main axis and comprising a nose section which is asymmetric with respect to said main axis of the warhead (14), said asymmetry being selected so that upon impacting and penetrating a target (22), at an angle which deviates from a perpendicular to a surface of said target (22), the forces acting on said nose section by said target, create a moment about a warhead's (14) center of gravity which directs the penetration warhead (14) in a direction which is substantially toward the perpendicular to the surface of the target (22), thereby increasing the warhead's penetration depth into the target (22).
2. The combination of claim 1, wherein said nose section includes a planar configuration at its anterior

end.

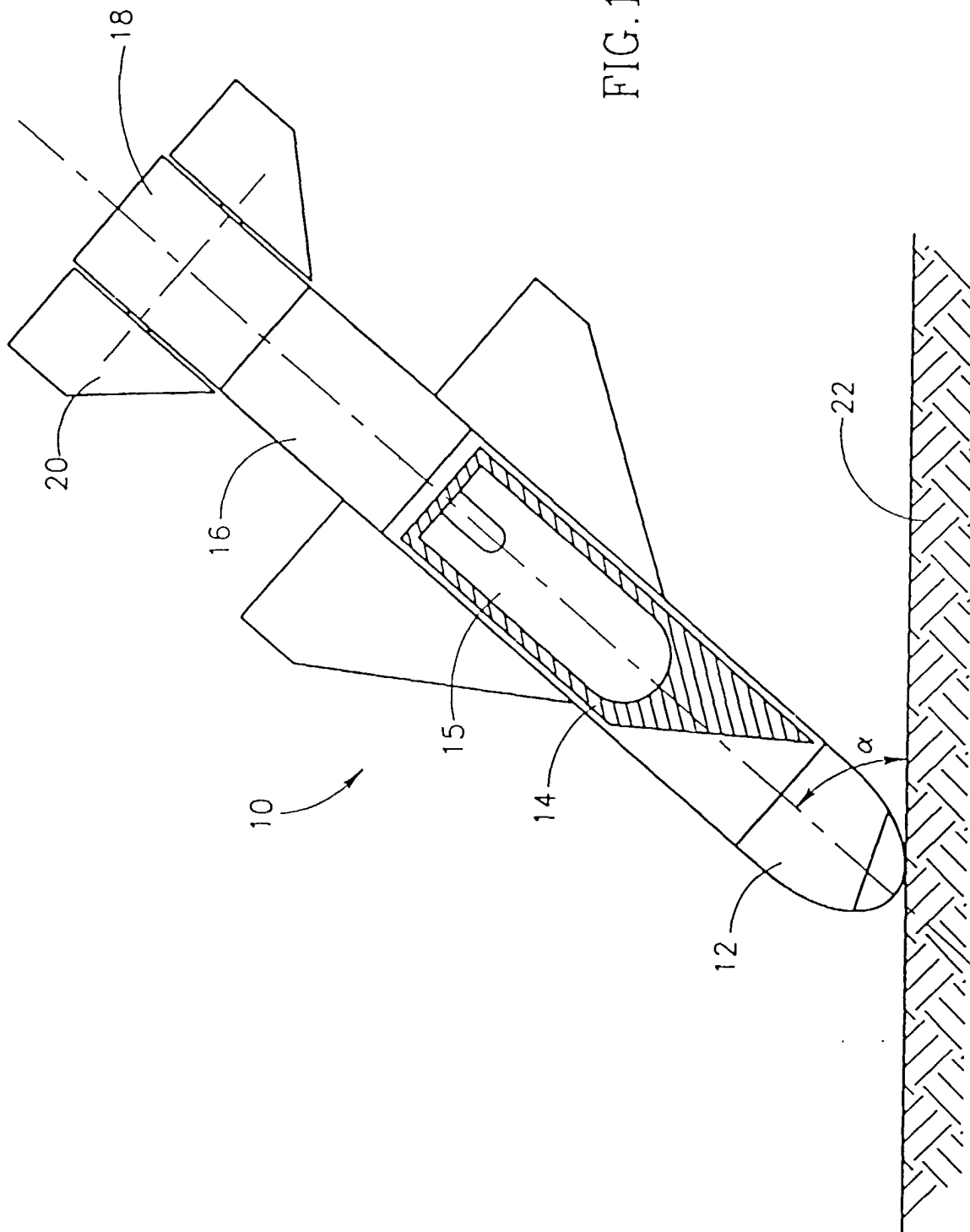
3. The combination of claim 1, wherein said nose section includes an oblique conical configuration at its anterior end.
4. The combination of claim 1, wherein said nose section includes a convex configuration at its anterior end.
5. The combination of claim 1, wherein said nose section includes a concave configuration at its anterior end.

Patentansprüche

1. Penetratorgeschoss (14) in Kombination mit einer Rakete (10) mit definierten oberen und unteren Teilen, wobei die Rakete (10) positionsgesteuert ist, um sicherzustellen, daß die Rakete mit aufwärts gerichtetem oberen Teil und nach unten gerichtetem unteren Teil fliegt, und wobei die Rakete (10) rollstabilisiert ist, um die Winkelposition der Rakete um deren Achse im wesentlichen konstant zu halten, wobei das Geschos (14) eine Hauptachse und einen Nasenabschnitt aufweist, der bezüglich der Hauptachse des Geschosses (14) asymmetrisch ist, wobei die Asymmetrie derart gewählt ist, daß beim Auftreffen auf ein Ziel (22) unter einem Winkel, der von einer Senkrechten auf eine Fläche des Ziels (22) abweicht, die auf den Nasenabschnitt von dem Ziel ausgeübten Kräfte ein Moment um den Schwerpunkt des Geschosses (14) erzeugen, welches das Penetratorgeschoss (14) in eine Richtung leitet, die im wesentlichen in Richtung der Senkrechten auf die Fläche des Ziels (22) verläuft, wodurch die Eindringtiefe des Geschosses (14) in das Ziel (22) vergrößert wird.
2. Kombination nach Anspruch 1, bei der der Nasenabschnitt an seinem vorderen Ende eine planare Ausbildung aufweist.
3. Kombination nach Anspruch 1, bei der der Nasenabschnitt an seinem vorderen Ende eine schräge konische Ausbildung aufweist.
4. Kombination nach Anspruch 1, bei der der Nasenabschnitt an seinem vorderen Ende eine konvexe Ausbildung aufweist.
5. Kombination nach Anspruch 1, bei der der Nasenabschnitt an seinem vorderen Ende eine konkave Ausbildung aufweist.

Revendications

1. Tête explosive pénétrante (14) en combinaison avec un missile (10) présentant des parties haute et basse définies, ledit missile (10) étant à position contrôlée, de manière à assurer que le missile vole avec la partie haute orientée vers le haut et la partie basse orientée vers le bas et ledit missile (10) étant à roulis stabilisé, afin de maintenir à peu près constante la position angulaire du missile autour de son axe, ladite tête explosive (14) présentant un axe principal et comprenant un segment de nez qui est asymétrique par rapport audit axe principal de la tête explosive (14), ladite asymétrie étant choisie de sorte que, lors de l'impact avec et la pénétration dans une cible (22) selon un angle qui s'écarte de la perpendiculaire à une surface de ladite cible (22), les forces agissant sur ledit segment de nez depuis ladite cible créent un couple autour du centre de gravité de la tête explosive (14) qui dirige la tête explosive pénétrante dans une direction qui va sensiblement vers la perpendiculaire à la surface de la cible (22), augmentant ainsi la profondeur de pénétration de la tête explosive dans la cible (22).
2. Combinaison suivant la revendication 1, dans laquelle ledit segment de nez comporte une configuration plane à son extrémité avant.
3. Combinaison suivant la revendication 1, dans laquelle ledit segment de nez comporte une configuration en forme de cône oblique à son extrémité avant.
4. Combinaison suivant la revendication 1, dans laquelle ledit segment de nez comporte une configuration convexe à son extrémité avant.
5. Combinaison suivant la revendication 1, dans laquelle ledit segment de nez comporte une configuration concave à son extrémité avant.



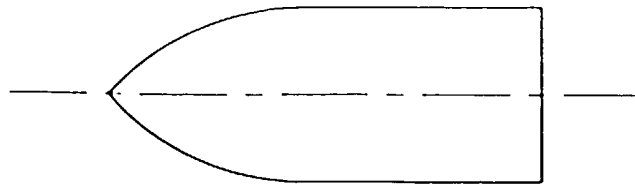


FIG. 2

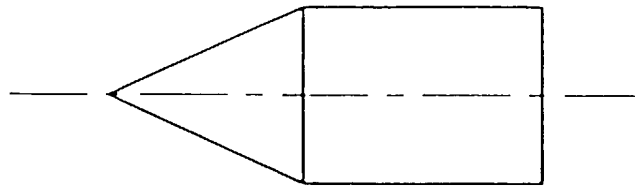


FIG. 3

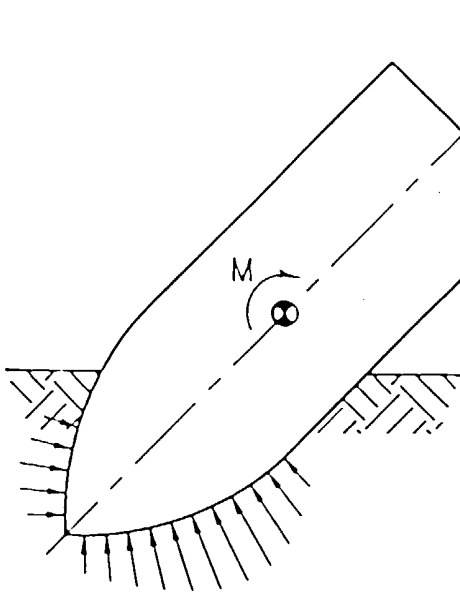


FIG. 8

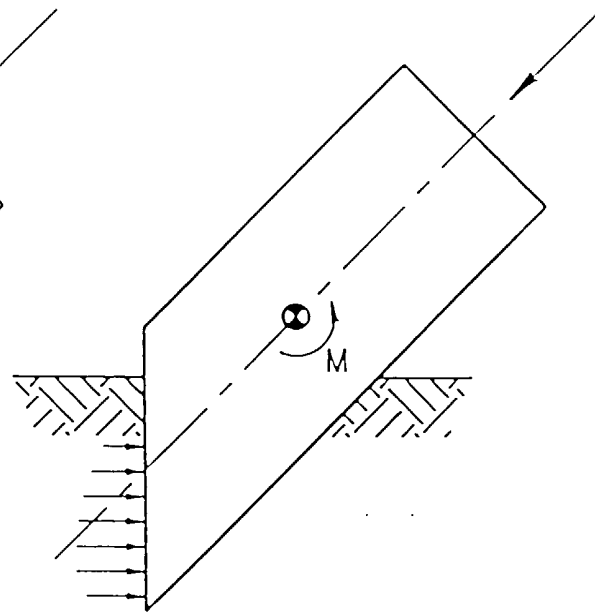


FIG. 9

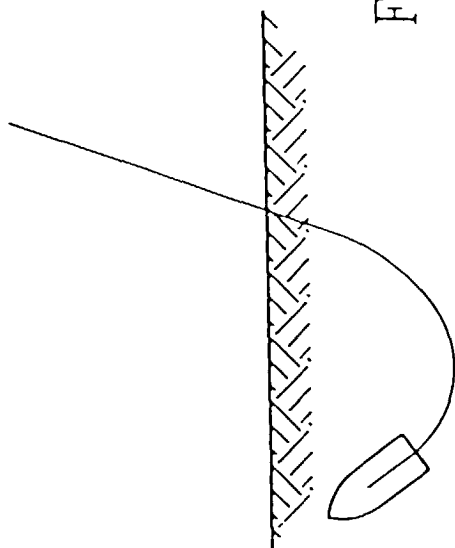


FIG. 5

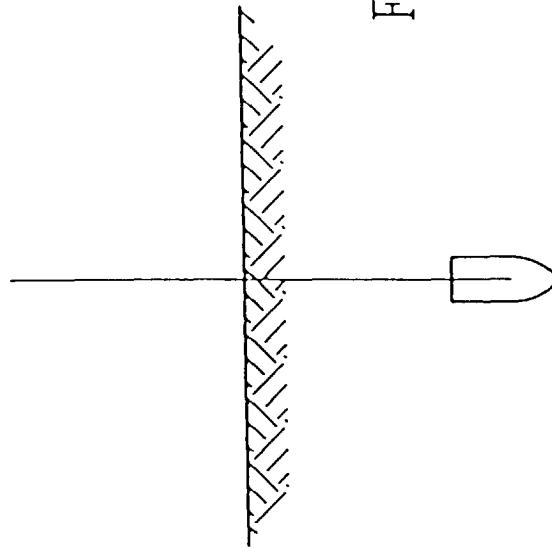


FIG. 7

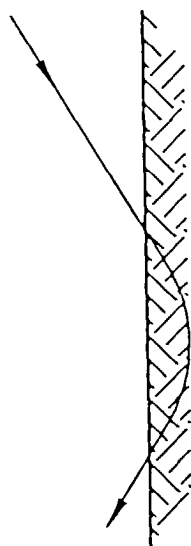


FIG. 4

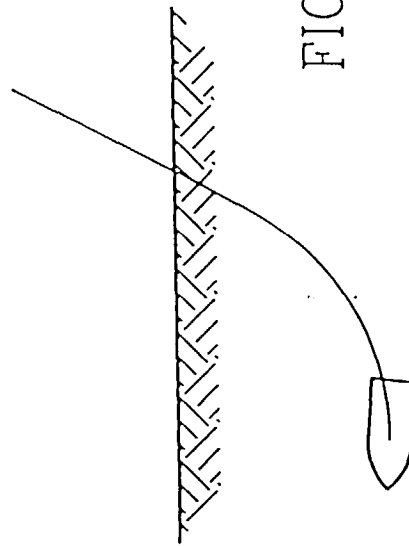
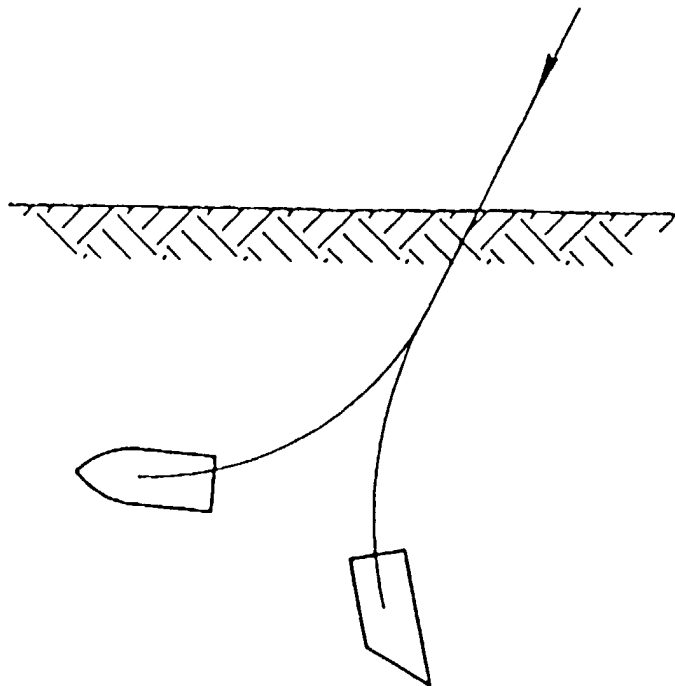
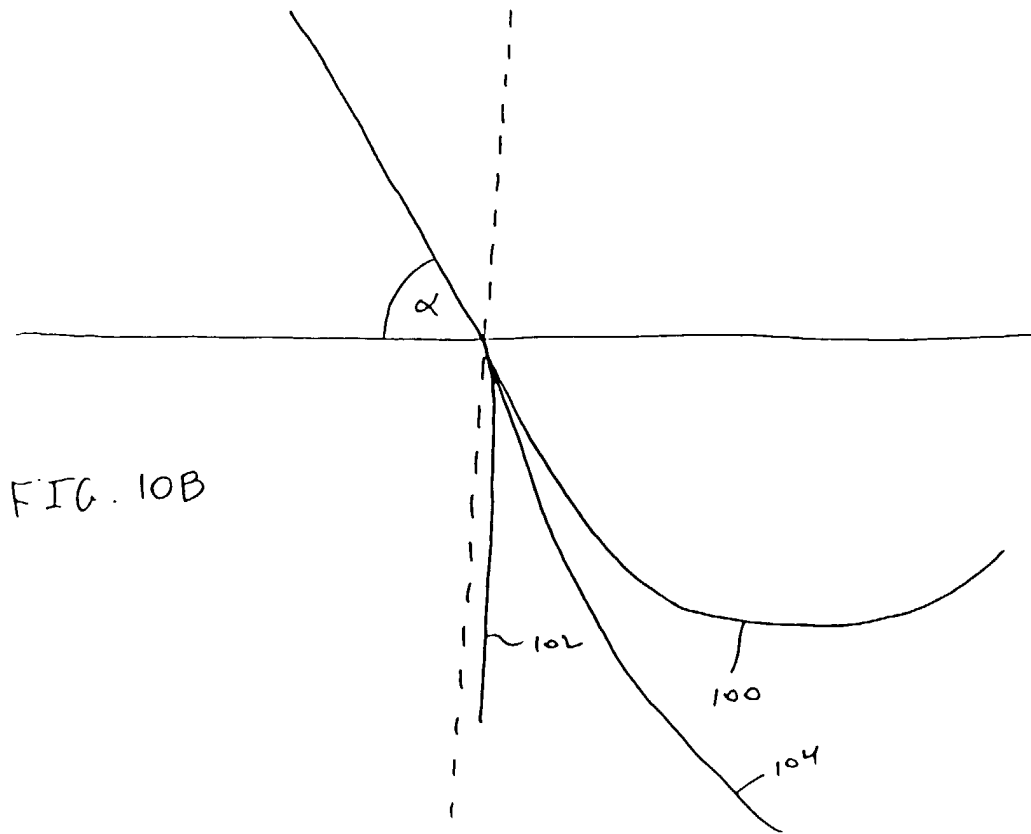
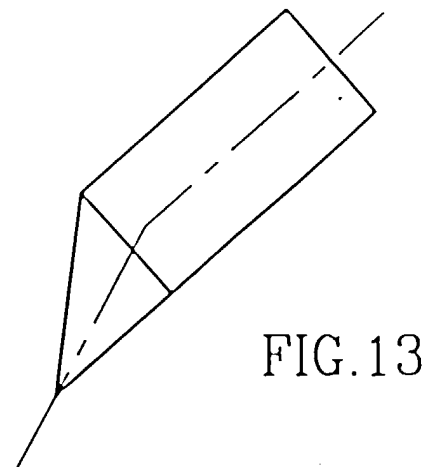
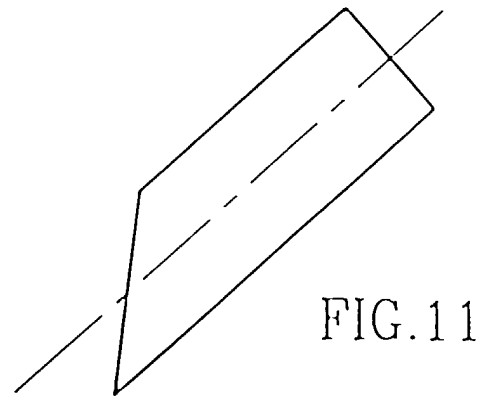
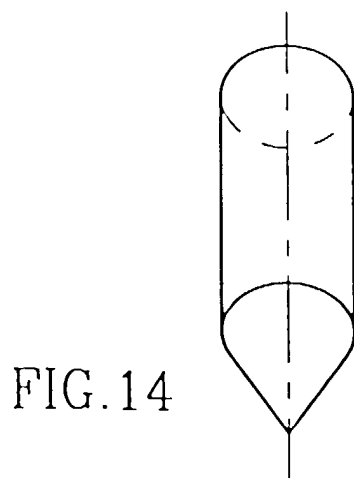
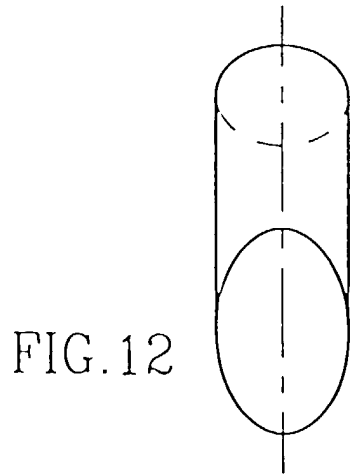


FIG. 6





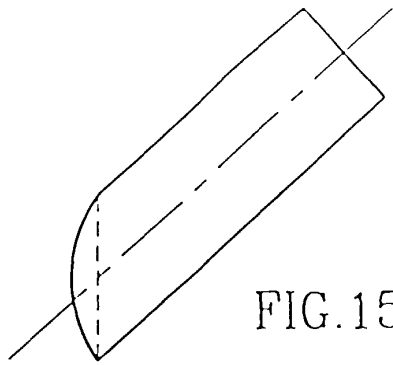


FIG. 15

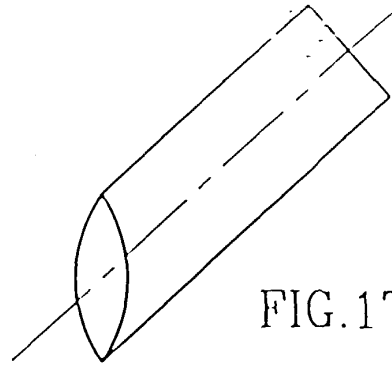


FIG. 17



FIG. 16



FIG. 18

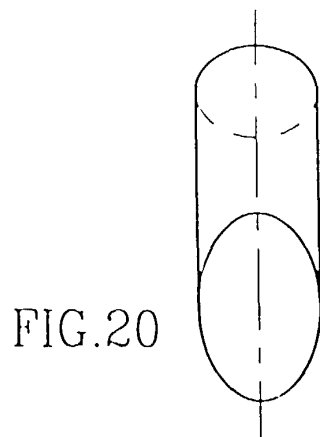


FIG. 20

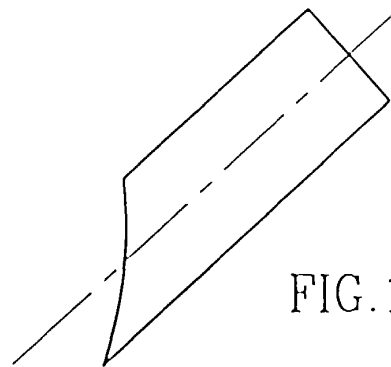


FIG. 19

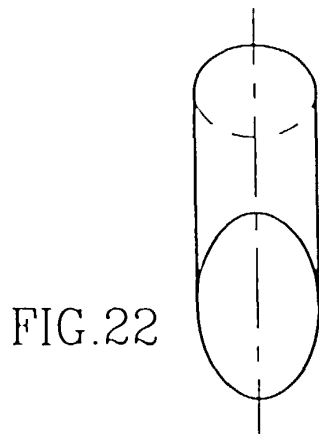


FIG. 22

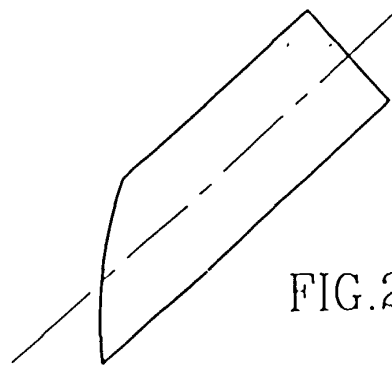


FIG. 21