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| <p>(21) International Application Number: PCT/GB86/00329<br/>(22) International Filing Date: 9 June 1986 (09.06.86)<br/>(71) Applicant: ROYAL ORDNANCE PLD [GB/GB]; Griffin House, 5 the Strand, London WC2 5BB (GB).<br/>(72) Inventor: FLATAU, Abraham ; 2004 Stockton Road, Joppa, MD 21085 (US).<br/>(74) Agent: McCORMACK, Derek, James; Royal Ordnance plc, Patents &amp; Licencing Dept., 2nd Floor, Griffin House, 5 The Strand, London WC2N 5BB (GB).<br/>(81) Designated States: AT (European patent), AU, BE (European patent), BR, CH (European patent), DE (European patent), DK, FR (European patent), GB (European patent), IT (European patent), JP, KR, NL (European patent), NO, SE (European patent).</p> |                  | <p><b>Published</b><br/><i>With international search report.</i></p>                                                                          |
| <p>(54) Title: <b>ARMOUR PIERCING PROJECTILE</b></p> <div> </div> <p>(57) Abstract</p> <p>An armour piercing projectile (10) having a carrier body (11) and a preferably high density penetrator core (12). The leading edge portion (15) of the carrier body (11) is preferably beveled and extends beyond the front end (14) of the penetrator core. Preferably encompassing the carrier body (11) is a nose shape (13) to provide relatively low aerodynamic drag during flight. The carrier body is designed to allow the projectile to be spin stabilised when fired from a suitable weapon.</p>                                                                                         |                  |                                                                                                                                               |

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## Armour piercing projectile

BACKGROUND OF THE INVENTIONField of the Invention

The invention relates to projectiles, and more specifically to armour penetrating projectiles which contain therein penetrator cores.

Brief Description of the Prior Art

Heretofore, two main types of armour piercing projectiles have been utilised. The earlier designs were of a conventional projectile shape and were of full-bore diameter, consisting of a lightweight material in the nose section and a hardened steel or high density material core behind the nose section forming the remainder of the projectile. This type of projectile had limited armour penetration capability. More recently it has been demonstrated that rod type penetrators fabricated of high density material are capable of penetrating more armour than the full-bore design. To take advantage of the rod's high ballistic coefficient and to provide increased initial launch velocities, sabots were designed to encapsulate the rod penetrator during handling, storage and gun firing, and to discard shortly after exiting the muzzle, thus allowing only the rod penetrator to continue in flight toward the target. The sabot discard process can introduce trajectory inaccuracies for the rod projectile, as well as representing a mass-energy loss.

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It is an object of the invention to provide an armour piercing projectile which overcomes the problems set forth in detail herein above by retaining all of the in-bore projectile components, and which are designed to contribute to the process of target penetration.

According to the present invention a composite projectile adapted to be fired from a gun bore to penetrate armour protected targets includes a rigid hollow carrier having an open forward-facing front end and a rear end relative to the direction of projectile movement toward a target surface, said carrier having an annular non-deformable leading edge at said front end, a penetrator core being adapted to fit in slidable relationship within said carrier and restrained within said carrier by a restraining member of said carrier whereby said penetrator is able to slide out of said carrier at its front end but not at its rear end, said core having a front end which is adapted to penetrate an armoured target and which, when said projectile is fired, is situated within said carrier aft of the leading edge of said carrier.

The projectile according to the present invention provides improved penetration of armoured targets, surprisingly without necessarily requiring the use of discarding components, in the unique manner described below by which both the carrier and the penetrator core contribute to the penetration process.

Preferably, the carrier is elongate and substantially cylindrical and has a sharp annular leading edge. The leading edge may be provided by a bevel on one or both of the inner and outer

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surfaces of the carrier which meet to provide the leading edge.

The rear end of the carrier may be tapered to reduce aerodynamic drag. The rear end of the core may be similarly tapered to be conveniently accommodated within the carrier.

The said restraining member may be a wall or collar defining the end of the bore into which the said penetrator core slidably fits. The rear end of the carrier may itself be closed and thereby provide the wall which acts as the restraining member. The penetrator core may be restrained in direct contact with the wall or by one or more intermediate members located between the wall and the core, e.g. as described further below.

Preferably, the penetrator core has a tapered front end which desirably terminates in a point. The taper may be provided as a single conical section or alternatively as a plurality of conical sections of different taper angle providing a gradual convergence to the front of the core of the profile of the core as seen in cross-section.

The front end of the core may however be an annular, preferably sharp, non-deformable leading edge. The core may be tubular or partly tubular and may include within the bore of the tubular portion a further member, slidably located in the bore. Such a member may itself provide a contribution to the target penetration process. Thus, it may, upon firing, have a front end which is situated behind the front end of the body of the core whereby penetration of the target is provided in a three-stage process by the carrier, core body and further member slidably fitted in the core body.

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The further member may have any of the forms described above which the core itself may have as a unitary structure.

The front end of the core may, for example, be situated approximately level with or behind the beginning of a bevel providing the leading edge of the carrier when the projectile is fired from a gun.

The core is preferably made at least in part of a high density material adapted to penetrate armour, e.g. of a tungsten alloy or depleted uranium. Such materials are well known per se to those skilled in the art. The front end of the core may be made of the said high density material although the front end may additionally include a tip of lighter material, e.g. steel, designed to provide greater initial penetration of a target surface as is known to those skilled in the art.

Preferably, the projectile according to the present invention additionally includes a nose secured to the carrier at or adjacent to its front end. Such a nose, which is preferably a fairing comprising a conical or rounded ogival thin-walled hollow structure, is adapted to serve as a shield reducing aerodynamic drag of the projectile during flight toward a target. The nose, which may be made of a lightweight material such as a plastics material or an aluminium alloy, is readily disintegrated upon striking a target. Carried material, e.g. incendiary or other material, may be enclosed in the cavity within the nose.

The carrier of the projectile according to the present invention may be formed of a single material, e.g. high strength steel, although it may alternatively comprise a plurality of dissimilar materials. For example, a forward

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portion including the leading edge of the carrier may be made of a high strength, high hardness material, e.g. high strength steel, while a rear portion may be made of a lighter material such as an aluminium alloy or a fibre reinforced composite material. Many such composite materials are well known to those skilled in the engineering materials art and may for example comprise fibres selected from one or more of carbon, boron, glass, aramid, metal, high strength plastics such as polyolefin embedded in a suitable matrix such as a thermosetting or a thermoplastic resin or a ceramic or metal. The dissimilar portions of the carrier may be attached together by any suitable technique well known in the engineering art, e.g. by screw threads or adhesive bonding. Preferably, the resulting carrier so formed comprises a single solid substantially cylindrical hollow mass.

As mentioned above, the penetrator core in the projectile according to the invention may, when fitted in the carrier for firing, contact directly the inner wall of the closed rear end of the carrier. Alternatively, the rear end of the carrier and the penetrator core may be separated by an intermediate member. For example, a slug may be provided behind the penetrator core. Such a slug may be made of material which is heavier than the penetrator core and which provides a greater impact force to the core when it strikes a target surface. Alternatively, the slug may comprise a capsule containing a carried material, e.g. a chemical agent, an explosive material, an incendiary material which scatters within a crew-compartment or the like after penetration. The outside of such a capsule may for example

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comprise a crushable plastics material or a composite or metal wall.

The core may conveniently be shaped at its rear end to receive the slug, e.g. by including a depression such as a spherical or conical cavity into which the slug rests.

The carrier, especially in its rear end, may carry a tracer, e.g. any of the tracers well known to those skilled in the art.

Unlike the series of Armour Piercing Discarding Sabot (APDS) projectiles in current use, the entire armour piercing projectile of this invention is designed to remain integral when fired from a gun. Retaining the carrier and designing it to be utilised to initiate the penetration process prior to the impact of the rod core has heretofore never been undertaken and successfully achieved. The benefit of improved penetration obtained by the composite projectile of the invention can however still be achieved even if the present composite projectile is itself a sub-calibre component of a larger round which could, for example, include a discarding sabot or other component.

In any event, the projectile according to the invention may be provided with any suitable means known to those skilled in the art to engage the rifled barrel of a gun in order to impart to the projectile rotational torque to provide suitable in-flight stability.

The gun from which the projectile according to the present invention is fired may comprise a small arms weapon, e.g. having a calibre up to 20mm, a medium calibre weapon e.g. in calibres from 20mm to 60mm, or a heavy weapon e.g. having a calibre greater than 60mm, although the invention

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is likely to find most use in small arms and medium calibre applications.

Embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view of one embodiment of this invention;

Figure 2 is a cross-sectional view of a second embodiment of this invention;

Figure 3 is a cross-sectional view of a prior art non-saboted high density core .50 inch calibre (12.7mm) projectile currently used;

Figure 4 is a cross-sectional view of the currently used prior art Air Force GAU-8 30mm high density core projectile;

Figure 5 is a cross-sectional view of the prior art Armour Piercing Discarding Sabot (APDS) Projectile as currently used in gun systems such as the 20mm Phalanx;

Figure 6 is a longitudinal view schematically illustrating the initiation of the penetration process as the projectile embodying the invention impacts the target;

Figure 7 is a longitudinal view schematically illustrating the continuation of the penetration process shown in Figure 6;

Figure 8 is a cross-sectional view of a third embodiment of this invention;

Figure 9 is a cross-sectional view of a fourth embodiment of this invention;

Figure 10 is a longitudinal view illustrating the initiation of the penetration process as the prior art currently used non-saboted high density core projectile impacts a target;

Figures 11 to 15 are cross-sectional views of various penetrator cores in further alternative embodiments of the invention.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in Figure 1, a full-calibre projectile embodying the present invention has an outward shape and symmetry very similar to those of conventional projectiles, providing an advantage not heretofore obtained with known discarding sabot projectiles. Major components or parts of this new projectile 10 include an elongate carrier 11, which may be made of steel, an elongate rod penetrator core 12, made of high density material such as tungsten alloy or depleted uranium, and a thin ogival nose shield 13 attached to the forward end of the carrier 11. The nose shield 13 may be made of plastics or aluminium, but in any case is preferably light in weight. It will be noted in Figure 1 that the core 12 has a front end in the form of a pointed nose 14 which is not aligned in a vertical plane with a beveled leading edge 15 of the carrier 11. Rather, the core nose 14 is deliberately placed aft or behind the leading edge 15 of carrier 11 with reference to the travel direction 25 of projectile 10. Preferably, the front of the nose 14 is approximately level with the start of the bevel providing the sharp leading edge 15 upon firing from a gun (not shown). This relative positioning is done to produce the following sequence of events and is based on the phenomena of interaction between the projectile 10 and the surface of impact.

Upon target impact, the sharp, annular beveled leading edge 15 of the carrier 11 produces a stress field in a target 50 as shown in Figure 6. As the stress waves meet in the target material, they combine and result in a wave

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amplitude increase (Figure 6) which is significantly larger than that produced by a conventional armour piercing projectile (Figure 10). This stress field in the target 50 material is then further increased or reinforced by the core 12 at the centre impacting the target 50 shortly after the initial impact by the sharp leading edge 15 of the carrier 11. The target material cannot resist the sudden or rapid stress loading and fails. In contrast, a conventional projectile penetrator 20 such as seen in Figure 3, upon initial impact with the target, will produce a series of non-reinforcing stress waves through the target as shown in Figure 10.

When the projectile embodying this invention is fired from a gun, the expanding propellant gases exert a positive force on the projectile base, which keeps the rod penetrator core 11 set back to the rear of the carrier 11 in the position shown in Figure 1. Upon target impact, the thin aerodynamic shield 13 is readily disintegrated. As the beveled leading edge 15 makes contact with the target 50, the projectile 10 is rapidly decelerated during the initial penetration process and the abrupt arresting of momentum causes the higher density rod penetrator core 12 which can slide inside the carrier 11 to be moved violently forward to add a second generation of impact stresses as shown in Figure 7. The stress field initiated by the beveled leading edge 15 of the carrier 11 is thereby supplemented by a second series of shock loading stresses concentrated in the same field, the overall effect being in the manner of a "one-two punch" which is far more damaging than a single punch by either penetration mechanism acting alone.

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The projectile shown in Figure 2 is similar in geometry to the projectile of Figure 1, except that the Figure 2 embodiment has been adapted to include an incendiary material 16 located inside the shield 13 and enclosed by the rod penetrator core 12 and the forward section of the carrier 11. It will be recognised that either embodiment, Figure 1 or Figure 2, could readily include a known tracer (not shown) in the base of the carrier body as will be readily apparent to those skilled in the art.

Figure 3 depicts a prior art .50 inch calibre (12.7mm) conventional anti-armour projectile 20 in current use. It consists of a high density material core 21 placed within an aluminium base carrier 22. The forward section of the projectile incorporates either a filler material such as a plaster or an incendiary material 23. The entire structure is encased by a thin gilding metal envelope 24. In contrast to the present invention, the only element of prior art projectile 20 involved in the target penetration process is the core 21.

As noted above, it is intended that the invention may be utilised in a wide range of guns, from handguns through to larger calibre guns and the projectile shape and size will vary according to the application. However, the same beneficial penetration phenomena discussed above with reference to Figures 6 and 7 will apply in the case of the geometric envelope of each specific projectile size or configuration. As an example of the range of different projectiles in current use, although the current .45 inch calibre (11.4mm) round has a short projectile length to diameter ratio, it is primarily intended for

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personnel who may be wearing armour vest type clothing; by contrast, the current 30mm GAU-8 projectile envelope, shown in Figure 4, allows for a much greater projectile length to diameter ratio, which then provides for a longer rod core, giving more mass and a higher ballistic coefficient for target penetration. This is entirely appropriate as the larger calibre projectiles are intended for anti-material purposes. The present GAU-8 anti-armour projectile 30 shown in Figure 4 consists of a high density material rod core 21 surrounded by an aluminium material 32 which forms the projectile configuration. Upon target impact, an aluminium windscreen 33 is readily broken up leaving the high density rod 31 to penetrate the target. This action produces only a single stage penetration stress pattern and is not capable of defeating heavy armour plate systems. The projectiles embodying the present invention may have an overall shape similar to that of these known projectiles.

Figure 5 represents a form of the current discarding sabot projectile as patented by Feldman (United States Patents Nos. 3,714,900 and 3,905,299). Note that sabot elements 42, 43 and windshield 44 must be discarded after leaving the gun muzzle (not shown) in order to allow the sub-calibre core 41 to continue toward the target without the considerable ballistic drag which would result from failure to discard such components. Besides the expense of producing sabot sub-assembly components instead of a single unitary sabot, there is a relatively greater risk of compromising performance in multiple-component sabots. Thus, the sabot must totally discard all

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its parts in a matter of micro-seconds, immediately when the round exits the gun muzzle, and without any angular or lateral non-symmetrical forces applied to the core 41 such as would disrupt its uninhibited trajectory even slightly. Any such aerodynamic perturbations during discard could cause the penetrator to miss the distant target or to alter its angularity at impact, which degrades its penetration effectiveness away from optimum design conditions. In contrast, the projectiles embodying this invention need not have discarding dead-weight, high drag masses or parasitic elements which do not contribute to the penetration process, and their accuracy need not be compromised by highly sensitive and unreliable sabot-discarding mechanisms.

Referring to Figure 8, a further embodiment of the present invention is seen for use where gun recoil and barrel forces are limited within a narrow performance force envelope, and excessive impulse loading could destroy the weapon by using projectiles having a higher mass than that the gun is designed to fire. To accelerate a projectile for armour piercing capability without exceeding gun total impulse design limitations, a decrease in projectile mass may be desirable. Therefore, in the embodiment shown in Figure 8, this is accomplished by forming the carrier 11 in two parts instead of a single unitary mass as shown in Figure 1. The Figure 8 modification shows carrier 11 comprising two structurally joined portions 26 and 18 made from two dissimilar materials. Forward portion 26 formed with the forward sharply beveled leading edge 15 is made of undeformable and high-hardness material such as high-strength steel, while aft or rear portion 18 is made of

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lighter weight material such as aluminium, reinforced plastics or strong and lightweight composite fiberglass or filament laminates of metallic, ceramic and non-metallic materials. Elements 26 and 18 are securely joined at their interface 19 by any suitable means such as screw-threads, various high-strength epoxy based adhesives, or any other assembly techniques known to the prior art and widely used in industry. When thus joined, elements 26 and 18 form a single solid, substantially cylindrical hollow mass which is dimensioned so as to grasp snugly the heavier and higher density penetration core 12 in the same manner that carrier 11 embraces and retains the core 12 in Figure 1.

Figure 9 shows a further modification of the inventive structure. In this case, wherein the mass slidably located inside the carrier 11 instead of being a simple homogeneous core 12 as in Figure 1, is composed of plural elements consisting of a front core 12 and a rear element 17. The core 12 has a generally conical pointed nose 14 and is made from high density, non-deforming material which may be the same as the materials discussed above for the core 12 shown in Figure 1. Element 17 behind the core 12 is of material different from the core 12, however, and may be heavier or lighter, depending upon the combat needs which the round is designed to fulfil. Thus, for example, the element 17 may be an elongate slug of material heavier than core 12, and may be positioned so as to add greater impact force to assist the core 12 at the time projectile 10 strikes a target surface. The core 12 shown in Figure 9 is provided with a depression such as a spherical or conical cavity at its aft

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or base end opposite from the nose 14. The element 17 has either a spherical or conical forward end portion which nests or bears against the aft cavity in core 12 as shown in Figure 9 in a symmetrical pattern of surface bearing contact. The element 17 may, alternatively, comprise a crushable plastics, composite, or metallic capsule containing a carried material. The precise composition of the carried material will depend upon the combat need to be served. Thus, the element 17 may for example comprise a chemical agent, an explosive material, or an incendiary material which scatters within a crew compartment or the like after penetration is achieved by the carrier 11 and the core 12.

In each of the above described embodiments of the present invention the penetrator core 12 has a pointed nose 14. The nose 14 is shown in each case as being of the same material as the body of the core 12 although it could have a tip of different material, e.g. steel where the core 12 body is of tungsten alloy or depleted uranium.

In the embodiments shown in Figures 11 to 15 various alternative forms of the penetrator core 12 only are shown in which the front of the core 12 is provided in each case by a sharp annular leading edge 64 instead of the pointed nose 14 shown in Figure 1.

In Figure 11 the core 12 is tubular and the leading edge 64 is provided by beveled surfaces 65 on the inside and outside of the tube.

In Figure 12 the shape of the core 12 is similar to that shown in Figure 11 except that only a front portion 66 of the core 12 is tubular. The core 12 in this case has a rear portion 67 which is solid. As shown, the rear

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portion 67 may be of different material, e.g. heavier material, than that of the front portion 66.

In Figure 13 the shape is similar to that shown in Figure 11. However in this case the tubular core 12 additionally contains a rod 68 slidably fitted within the core 12. The rod 68 is, upon firing of the projectile, set back within the bore of the core 12 in the same manner that the core 12 is itself set back within the carrier 11 as described with reference to Figure 1. Thus, the carrier 11, tubular core 12 and rod 68 serve in this case to provide a three stage target penetration process instead of the two stage process described with reference to Figure 7.

In Figure 14 the annular leading edge 64 is provided at the front of a conical portion 69, the edge 64 being sharply formed by a slot 61 machined in the front of the core 12.

The embodiment shown in Figure 15 is similar to that shown in Figure 14 except that in Figure 15 the body of the core 12 is tubular. In a similar alternative embodiment (not shown) to that shown in Figure 15 the rear end only of the core 12 may be tubular.

In each of the embodiments shown in Figures 11 to 15 the core 12 is to be fitted in its carrier 11 in the manner shown in Figure 1 and a nose 13 is to be fitted on the front of the carrier 11, also as shown in Figure 1.

In all embodiments of this invention, the cavity inside the nose 13 may be used for loading useful carrier material other than incendiary material (as mentioned).

Any of the projectiles according to the present invention fired from the bore of a gun are

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spin stabilised in flight. The carrier (e.g. carrier 11) may include any suitable means to engage the rifled barrel of a gun to impart the necessary rotational torque, e.g. a driving band or pusher/obturator may be used as will be apparent to those skilled in the art.

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Claims:

1. A composite projectile adapted to be fired from the bore of a gun to penetrate armour protected targets, the projectile including a rigid hollow carrier having an open forward-facing front end and a rear end relative to the direction of projectile movement toward a target surface, said carrier having an annular non-deformable leading edge at said front end, a penetrator core being adapted to fit in slidable relationship within said carrier and restrained within said carrier by a restraining member of said carrier whereby said penetrator is able to slide out of said carrier at its front end but not at its rear end, said core having a front end which is adapted to penetrate an armoured target and which, when said projectile is fired, is situated within said carrier aft of the leading edge of said carrier.
2. A projectile as claimed in claim 1 and wherein the carrier is elongate and substantially cylindrical and has a sharp annular leading edge.
3. A projectile as claimed in claim 1 or claim 2 and wherein the core has a conical forward facing end which terminates in a point providing the front end of the core.

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4. A projectile as claimed in claim 1, claim 2 or claim 3 and wherein the rear end of the carrier is closed, the said restraining means being provided by the wall of said rear end.
5. A projectile as claimed in claim 1 and wherein the core is made at least in part of a high density material.
6. A projectile as claimed in claim 5 and wherein the high density material is selected from tungsten alloy and depleted uranium.
7. A projectile as claimed in claim 1 or claim 2, and further including a thin-walled hollow fairing secured to said carrier at or adjacent to its front forward end and adapted to reduce aerodynamic drag of said projectile during flight toward a target.
8. A projectile as claimed in claim 7, and wherein said fairing enclosed an incendiary material.
9. A projectile as claimed in claim 1 and wherein said carrier comprises an elongate base portion of relatively lightweight material and an elongate forward portion of material heavier than said lightweight material, said base portion and said forward portions being secured together in fixed relationship with each other.
10. A projectile as claimed in claim 1 and wherein a slug of carried material is located between the core and the rear end of the carrier.

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Fig.1.

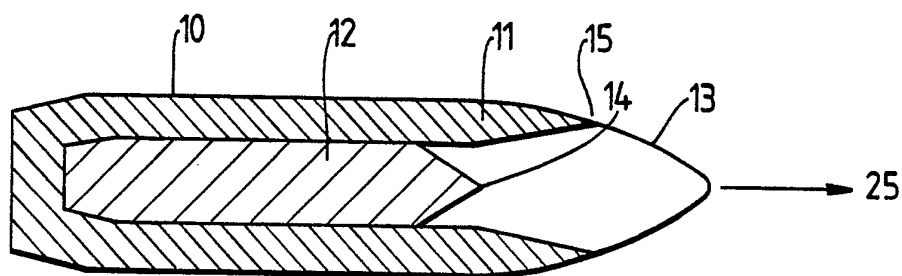


Fig. 2.

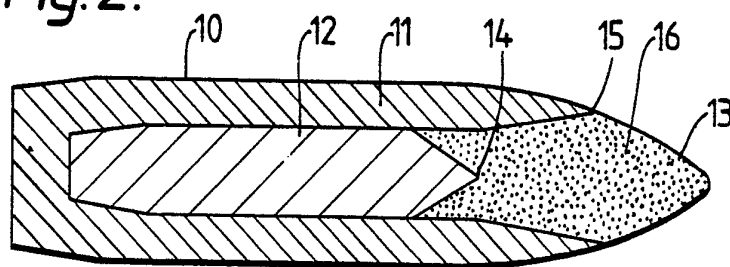


Fig.3.  
PRIOR ART.

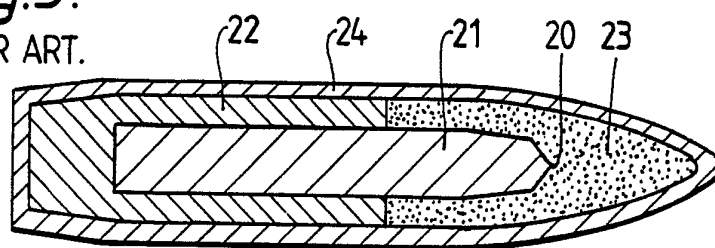
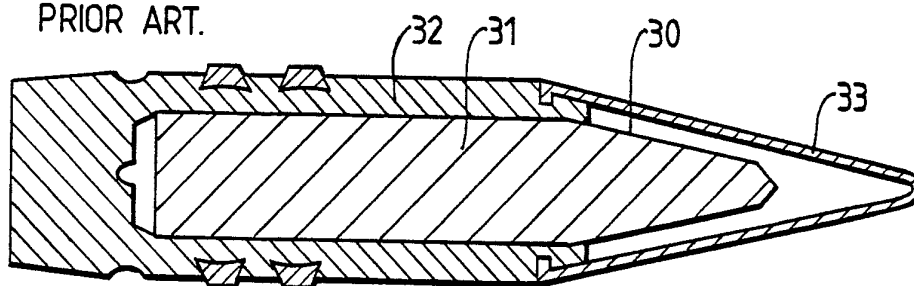


Fig.4.  
PRIOR ART.



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*Fig. 5.*  
PRIOR ART.

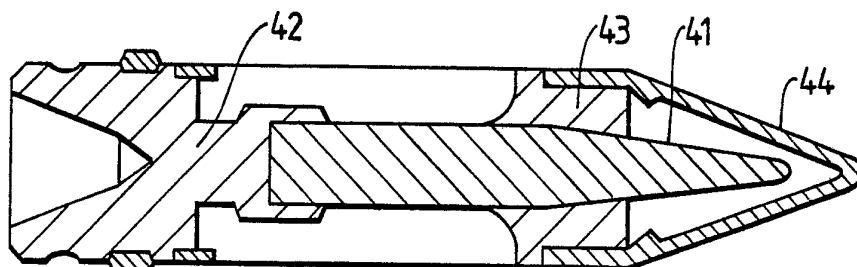


*Fig. 6.*

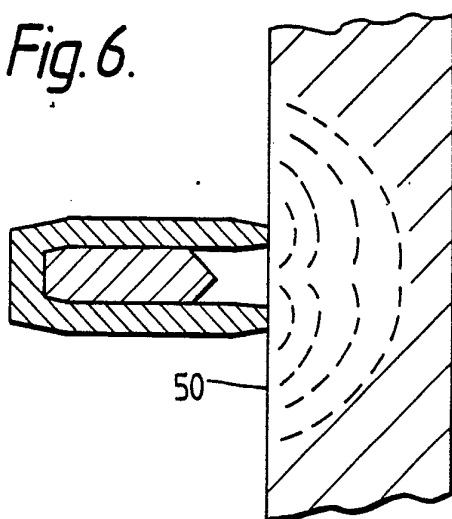


*Fig. 7.*

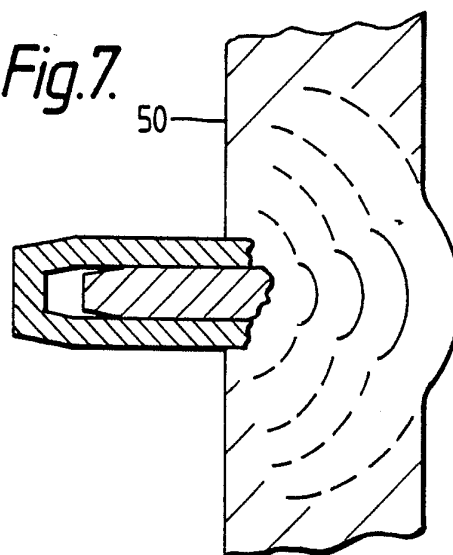


*Fig. 8.*

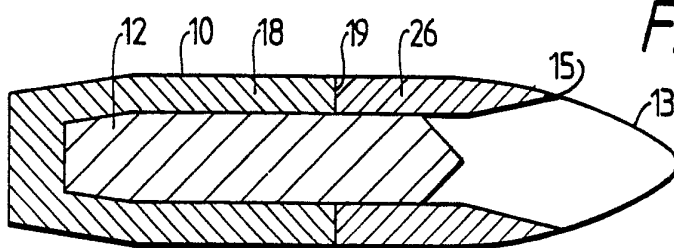


*Fig. 9.*

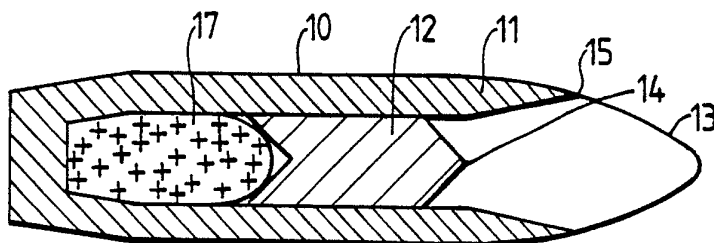


Fig.10.

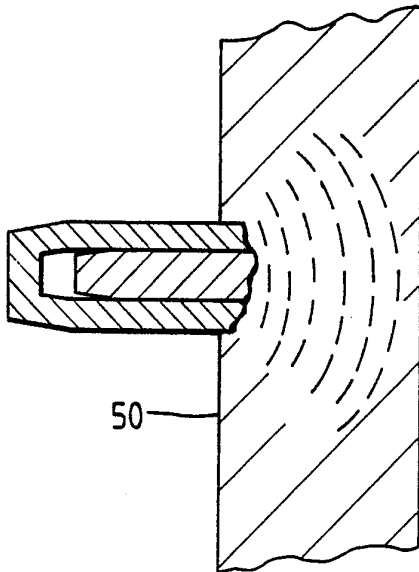


Fig.11.

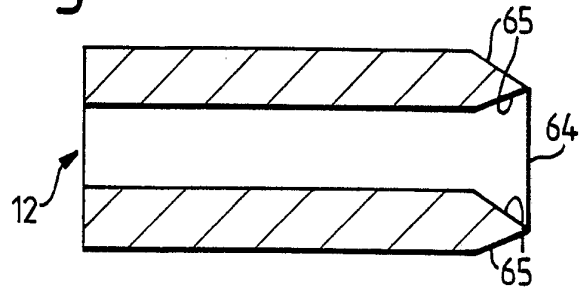


Fig.12.

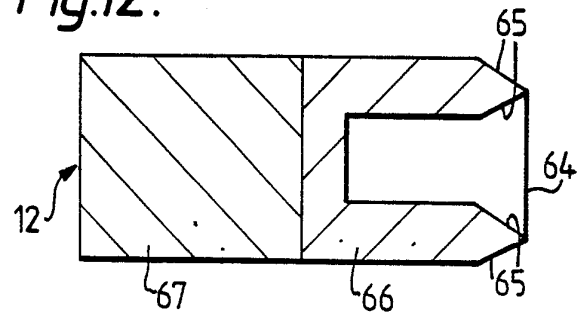


Fig.13.

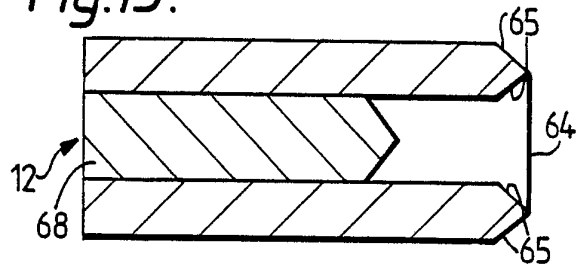


Fig.14.

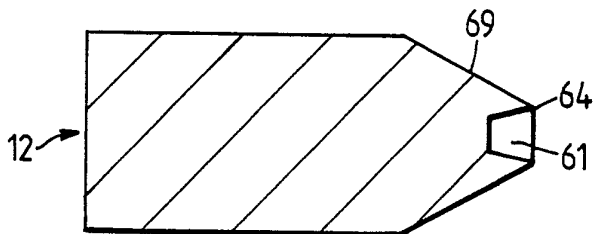
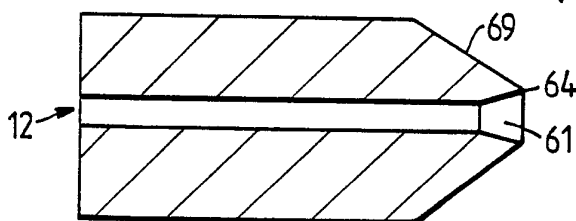
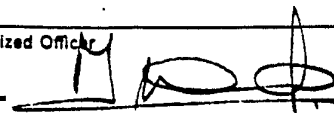


Fig.15.



# INTERNATIONAL SEARCH REPORT

International Application No. PCT/GB 86/00329

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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| <b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) *                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                        |                                     |
| According to International Patent Classification (IPC) or to both National Classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                        |                                     |
| IPC <sup>4</sup> : F 42 B 13/06                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                        |                                     |
| <b>II. FIELDS SEARCHED</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                        |                                     |
| Minimum Documentation Searched <sup>7</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                        |                                     |
| Classification System                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Classification Symbols                                                                                                                 |                                     |
| IPC <sup>4</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | F 42 B                                                                                                                                 |                                     |
| Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched <sup>8</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                        |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                        |                                     |
| <b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup></b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                        |                                     |
| Category <sup>9</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>                         | Relevant to Claim No. <sup>13</sup> |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | US, A, 4435887 (STRANDLI et al.)<br>13 March 1984, see column 1, lines 13-18; column 2, lines 64-68; column 3, lines 1-17; figures 1-4 | 1,3-5,7,8                           |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | --                                                                                                                                     | 2,6                                 |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | US, A, 3302570 (MARQUARDT) 7 February 1967,<br>see column 2, lines 8-58; figures 1,2                                                   | 2,6                                 |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | FR, A, 2356906 (RAUFOSS) 27 January 1978,<br>see page 2, lines 39-41; page 3;<br>page 4, lines 1-11; figures 1-3                       | 1,3-5,7,8                           |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | GB, A, 572732 (MOSEY) 22 October 1945,<br>see page 2, lines 63-130; figures 1,2                                                        | 1-3,7                               |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | --                                                                                                                                     | 10                                  |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | FR, A, 333930 (DEUTSCHE WAFFEN- UND<br>MUNITIONSFABRIKEN) 7 December 1903,<br>see the whole document                                   | 10                                  |
| --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                        |                                     |
| <div style="display: flex; justify-content: space-between;"> <div style="width: 48%;"> <p>* Special categories of cited documents: <sup>10</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 48%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p> </div> </div> |                                                                                                                                        |                                     |
| <b>IV. CERTIFICATION</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                        |                                     |
| Date of the Actual Completion of the International Search                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Date of Mailing of this International Search Report                                                                                    |                                     |
| 6th January 1987                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 10 FEB. 1987                                                                                                                           |                                     |
| International Searching Authority                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Signature of Authorized Officer                                                                                                        |                                     |
| EUROPEAN PATENT OFFICE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | M. VAN MOL                                         |                                     |

| III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET) |                                                                                    |                      |
|----------------------------------------------------------------------------|------------------------------------------------------------------------------------|----------------------|
| Category*                                                                  | Citation of Document, with indication, where appropriate, of the relevant passages | Relevant to Claim No |
| A                                                                          | US, A, 4108073 (DAVIS) 22 August 1978,<br>see column 2, lines 33-41<br><br>-----   | 6                    |

# ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 86/00329 (SA 13607)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 21/01/87

The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent document<br>cited in search<br>report | Publication<br>date | Patent family<br>member(s)                                                                                                         | Publication<br>date                                                                          |
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| GB-A- 572732                                 |                     | None                                                                                                                               |                                                                                              |
| FR-A- 333930                                 |                     | None                                                                                                                               |                                                                                              |
| US-A- 4108073                                | 22/08/78            | None                                                                                                                               |                                                                                              |

For more details about this annex :  
see Official Journal of the European Patent Office, No. 12/82