

Lead-free Projectile

Description

The present invention relates to a lead-free small-bore jacketed projectile.

Such ammunition is known in various designs. It may be divided into those with hard cores made of steel, into those with hard cores made from dense sintered material and those with a medium additional to the hard core such as lead, aluminium and/or air. Together with this commercially available ammunition is a steel jacket, generally configured as a full jacket, i.e. a plated steel jacket or a jacket made from a copper/zinc alloy (tombac jacket). In this connection, the jacket receives one or more cores and further media and encloses said cores and media at least in a liquid-tight manner.

Small arms ammunition and the manufacturing process thereof is known from EP-A2-0 106 411. The correspondingly optimised projectiles principally serve as live ammunition for infantry and already have good aerodynamic properties. This ammunition, however, does not have the required high final ballistic energy required by marksmen, which is necessary for penetrating armour plating. A further drawback is the large amount of hard lead (98% Pb + 2% Sn) in the core, which has a toxic effect on the environment both in blank ammunition and live ammunition and therefore is undesirable nowadays or even prohibited in some countries.

A jacketed projectile (WO 99/10703) of increased penetration performance and target accuracy has a hard core made of tungsten carbide and, as an additional medium, a soft core made of lead (Pb/Sn 60/40) which are held with an interference fit in a gastight manner via a brass disc in the jacket. Thus, the escape of heavy metals and/or vapour when firing is prevented; a toxic effect is, however, still present in the target area. Additionally, the manufacture of such a projectile is costly and too expensive for mass use (infantry ammunition).

A further jacketed projectile for 9 mm bore pistols is marketed under the reference SWISS P SELF 9 mm Luger (RUAG Ammotec, Thun/Switzerland, formerly RUAG ammunition

Thun/Switzerland). In this case, the projectile consists of two sleeves pushed inside one another, the inner sleeve sealed at the tail and open upwards, enclosing a large air space with the outer sleeve. This projectile is, however, only designed for soft targets and, in this case, is able to be driven through smoothly; it may be manufactured as lead-free.

A jacketed projectile with a bore of up to 15 mm is known from DE-A1-107 10 113 which comprises an ogival or conical front region, a cylindrical central part and a conically extending tail region. The ductile metallic jacket encloses a pointed hard core made of hardened steel or made of a sintered metal and is more or less freely held by a shoe-like or sheath-like support made from a ductile metal or made of synthetic material. The core is only in linear contact with the jacket in the region of its angular shoulder. The penetrative action of this projectile on armour plated targets is good; the target accuracy thereof is however, markedly reduced. In particular with an oblique impact on the target, the front part of the projectile jacket splinters and deforms and thereby presses the hard core out of its initial symmetrical axial position which, as the effective cross-section has become greater, at least reduces the penetration performance or even leads to ricochets. Additionally, the manufacture of the projectile is costly and, due to the more or less free positioning of the hard core, may not be carried out with great accuracy.

It is therefore the object of the invention to provide a small-bore projectile (small-bore = bore less than 0.5") suitable for hard targets, which may be manufactured economically, has a high penetration performance and target accuracy and does not release heavy metals on firing or in the target area. The projectile to be provided is intended, in particular, to contain no lead in the core. The projectile jacket is also intended not to splinter on a hard target.

The projectile according to Claim 1 may be easily manufactured and in a hard target (sheet metal) etc. transmits almost the entire kinetic energy to the hard core which penetrates the target. In this connection, the mass remains preserved at 100%; at the bullet hole a mushroom-shaped collar is formed by the tombac jacket which corresponds to the original weight of the jacket

Thus it is proved that no heavy metals and/or metal vapour are released.

The same may be detected for the subject of the invention according to Claim 2. This exhibits a high final ballistic performance, despite there not being a hard core over the entire surface in cross-section, in practical tests no fragmentation was detected at the target.

Advantageous developments of the subject of the invention are disclosed in the dependent claims.

A projectile with an ogive-like outer shape and an air space according to Claim 3 is particularly advantageous with regard to ballistics. It has been shown, that the necessary pressing-in of the hard core may be carried out accurately and with relatively low forces. Additionally, the pulse transmission of the core, after a short displacement path, allows a penetration of the jacket with lower energy losses.

The embodiment according to Claim 4 is very advantageous for the central pulse transfer from the jacket core to the hard core.

To a considerable extent, the flying behaviour of the projectile is provided by the position of the centre of gravity, Claim 5. The centre of gravity may be optimised by the constructive design and dimensioning of the hard core and, in particular, of the hollow space (bore) in the jacket core.

Alloy tool steels are well suited to the hard core and may be machined and surface-treated by conventional means. Claim 6.

Identical materials for the outer jacket and the jacket core according to Claim 7 have proved to be very economical and also expedient with regard to the density, the assembly and the thermal expansion.

A constriction according to Claim 8 improves the connection to the cartridge sleeve and allows the simple assembly thereof.

The thickening of the jacket in its front region described in Claim 9 reduces ricochets during acute angle firing at hard targets and also serves to determine the centre of gravity.

The aforementioned embodiments of the projectile appear to be particularly suitable for the bore and projectile types cited in Claim 10.

The current demand for lead-free projectiles is ensured with the choice of material revealed in the claims; see Claim 11. Standard filling material made of heavy metal in conventional projectiles may also be dispensed with, as the position of the centre of gravity may be optimally adjusted by the dimensioning of the individual components and hollow spaces.

The invention is disclosed hereinafter with reference to the embodiments and drawings, in which:

Figure 1 is a projectile according to the invention, fitted into a cartridge sleeve known per se,

Figure 2 is a sectional view through a preferred embodiment of the projectile in Figure 1,

Figure 3 is a sectional view of an alternative solution of a lead-free projectile,

Figure 4a is a conventional projectile (according to the prior art) when striking the target

Figure 4b is a projectile according to Figure 2 when striking the target
and

Figure 4c is a projectile according to Figure 3 when striking the target.

The tip of a projectile 100 is denoted in Figure 1 by 1. A flange 21 is inserted into the reduced diameter of a peripheral constriction 6, and which is a component of a cartridge 20 known per se. A standard explosive 24 is located in the cartridge 20, which acts as a propellant for the projectile 100. An impact fuse 23 (SINTOX, trademark of the firm RUAG Ammotec GmbH, Fürth, DE) is inserted in a base 22 of the cartridge 20.

The preferred rotationally symmetrical projectile 100 is visible in Figure 2 in an enlarged sectional view.

The actual tip 1 is imaginary; in reality it is a tip in the shape of a spherical cup 2. A small air space 3 is located inside the projectile 100, which is formed between a hard core 4 and an outer jacket 5, as a result of the different radii. A jacket core 8 is attached to the hard core 4 with form fit, and which has a central hollow space 10 in the form of a blind hole. The centre of gravity 7 of the projectile is located in the upper part of said hollow space. An outer peripheral annular groove 6 is located thereover, which is illustrated here, portrayed as a diameter; see Figure 1.

At the tail, the end of the jacket 5 is conically tapered and terminates in a stepped portion at an angle α of 30° , which stepped portion merges with a terminal flange 9 and holds the two cores 4 and 8 together with an interference fit.

The diameter of the projectile 100 denoted by K, the bore, in the present case is 5.56 mm and is of the SS 109 type. The diameter 6 of the constriction is 5.45 mm. The hard core 4 weighs 4 g and is made of hardened tool steel (material according to DIN 1.5511) and has been phosphatised after carburizing (penetration depth = 0.3 - 0.5 mm). The surface hardness is 570 HV1.

In this embodiment, the hard core 4 has a lower conical tip of 90° which rests positively in a corresponding recess (countersink) in the upper part of the jacket core 8. This configuration may be varied at will; a similar form of central centering action is, however, advantageous, which facilitates the insertion or pressing-in of the core and ensures the rotational symmetry of the projectile.

A hard core 4 made from tombac has also proved expedient; surprisingly, this produces a similar final ballistic performance.

The projectiles may be manufactured by standard production devices and substantially by deep drawing and pressing.

The hard core may also be made from other materials, for example from sintered materials such as tungsten carbide. Other projectile jackets are also conceivable, which have a similar ductility to tombac. The jacket core may also consist of other materials which have a similar or greater density. In all alloys, however, consideration has to be given to the deposition of heavy metal during firing and at the target.

In Figure 3 a variant of the aforementioned projectile is shown, in this connection the same functional parts are provided with the same reference numerals.

In contrast to the subject according to Figure 2, in this case, the hard core is dispensed with. A single jacket core 8' similarly fills up the space of the hard core 4, in Figure 2. The associated hollow space 10' is shortened relative to the hollow space 10 and has a smaller diameter. As a result, the mass of the entire projectile 100' is increased, so that approximately the same final ballistic performance and effect is achieved at the target.

On the front face, the hollow space 10' tapers and is at least almost closed so that, together with the front part of the outer jacket 5, a compact tip is produced when striking the target.

In both variants, measuring results, theoretical observations and comparisons with other projectiles (prior art) show exceptionally good results:

The hollow space 10 and/or 10' allows a transverse contraction in the gun barrel (rifle) which, relative to solid projectiles, leads to a reduction in wear (abrasion), in particular in the rifling grooves. At the same time, the firing velocity v_0 of the projectile 100 and/or 100' at the muzzle is greater than with projectiles without a hollow space 10 and/or 10'.

The low drag coefficient c_d of a 5.56 mm projectile (SS109 type) according to the invention, after a 570 m flight distance (NATO target), still lead to an impact velocity of 470 m/s; the steel plate used was Stanag 4172 of 3.5 mm thickness with 55-70 HRB hardness (400N/mm^2) and was perforated smoothly.

The precise spin stabilisation acts positively on the stability and reproducibility of the flight path, even with side wind. As a result of the choice of materials and the high firing velocity, the kinetic energy is greater than with comparable projectiles, as tests also showed. The precision of a standard weapon may be increased with the subject of the invention. Thus, for example, all fired shots (repeated fire) at a target distance of 25 m were located in a dispersion circle with a diameter < 50 mm. At a firing distance of 300 m, a standard deviation $S_D < 35$ mm could be detected. In practice, this means that of 20 fired shots, of which 18 are located in a circular surface with a diameter of 110 mm, only two projectiles struck approximately 80 mm offset from the centre (target).

As tests in firing against soap have shown, the requirements of the ICRC (International Committee of the Red Cross) are also completely fulfilled, with regard to wound ballistics, in contrast with numerous other projectiles according to the prior art.

Figure 4a shows a conventional hard core projectile 200 (prior art) before and during impact on the target Z (steel). The steel jacket 50 explodes at the target Z, a hard core 40 consisting of tungsten or steel penetrates the target Z, whilst, due to the high kinetic energy, the lead core 30 which follows behind is partially liquefied and even partially vaporised by sublimation on impact. This may be seen by a vapour cloud 30' which, after the condensation thereof, also leaves traces of lead at the target.

A combination of elastic and plastic impact with high deformability takes place in the projectile 200 (fragmentation of material on all sides). The material of the projectile 200 which is splintered at the target Z and which may still be detected, no longer corresponds to its initial weight at the muzzle.

In contrast, on one projectile 100, in Figure 4b, the identical mass may also be detected at the target Z. In this connection, the hard core 4 (steel or tombac) also penetrates the target Z. The outer jacket 5 mushrooms up at the target Z into a deformed jacket 5' and transmits almost 100% of the kinetic energy to the hard core 4 via its similarly ductile jacket core 8; there is no fragmentation of material, either on the jacket 5 or on the jacket core 8. The pulse direction remains preserved.

Figure 4c shows a similar view: the projectile 100' which is modified relative to Figure 4b is squashed at the target Z and penetrates with a tip 1' which is now flattened. The pulse direction also remains preserved, the jacket core 8' is displaced on impact into the air space 3, compressed and squashed which is denoted here by 8".

List of Reference Numerals

1	Tip (imaginary)
1'	Flattened, squashed tip
2	Spherical cup
3	Air space (hollow space)
4	Hard core (hardened steel; tombac)
5	Outer jacket (tombac)
5'	Deformed jacket 5
6	Constriction/diameter
7	Centre of gravity
8	Jacket core
8'	Jacket core
8"	Squashed jacket core 8'
9	Flange at 5
10	Hollow space in 8
10'	Hollow space in 8'
20	Cartridge sleeve
21	Flange at 20
22	Base of 20
23	Impact fuse
24	Explosive/propellant
30	Lead core
30'	Vapour cloud made up of Pb
40	Hard core (tungsten; steel)
40'	Lead vapour (sublimated Pb)
50	Steel jacket
100, 100'	Projectiles
200	Conventional hard core ammunition (projectile)

K	Bore
Z	Target (steel plate)
α	Angle (base angle)

Claims

1. Small-bore projectile (100) with an ogival or conical front region, a cylindrical central part and a conically extending tail region, consisting of
 - an outer jacket (5) made of a copper/zinc alloy, the jacket (5) enclosing a hollow space (3),
 - a hard core (4) made of steel or a sintered material inserted into the hollow space towards the tip,
 - a jacket core (8) made of a copper/zinc alloy attached with form fit to the hard core (4), with a cylindrical hollow space (10) open on the front face,
 - the open face of the hollow space (10) comprising a conical front face and positively resting against the hard core (4) and sealing said hard core at the front face and
 - the jacket core (8) being in contact on the periphery over its entire length at least by the tail region of the jacket (5) and held with an interference fit.
2. Small-bore projectile (100') with an ogival or conical front region, a cylindrical central part and a conically extending tail region, consisting of
 - an outer jacket (5) made of a copper/zinc alloy, the jacket (5) enclosing a hollow space (3),
 - the hollow space of the jacket (5) solely containing a jacket core (8') with a hollow space (10'),
 - the hollow space (10') comprising an aperture tapering on the front face, the inner edge regions thereof being at least partially in contact with one another,

- the jacket core (8') being in contact on the periphery over its entire length by the jacket (5) and held with an interference fit.
3. Small-bore projectile according to Claim 1, with an ogive-like front region, the tip thereof being configured at least approximately in the shape of a spherical cup,
- the cylindrical hollow space in the front inner region being defined in the shape of a spherical cup,
 - the hard core (4) at its tip also having the shape of a spherical cup,
 - the radius of the spherical cup of the hollow space being larger than the radius of the tip of the hard core, so that in the hollow space of the jacket, in the tip thereof, an air space (3) remains.
4. Small-bore projectile according to Claim 3,
- the tail region of the hard core (4) being of conical configuration and
 - the conical tip protruding into the hollow space (10) of the jacket core (8).
5. Small-bore projectile according to one of Claims 1 to 4,
- the centre of gravity (7) of the projectile being located in the longitudinal axis and in the region of the hollow space (10) of the jacket core (8).
6. Small-bore projectile according to Claim 1 or 3,
- the hard core (4) consisting of an alloyed tool steel or sintered material of high density, such as tungsten carbide.

7. Small-bore projectile according to Claim 1 or 2,
 - the outer jacket (5) and the jacket core (8) consisting of the identical copper/zinc alloy.
8. Small-bore projectile according to Claim 1, 2 or Claim 5,
 - the outer jacket (5) comprising a circumferential, peripheral constriction, on which the front end (21) of a cartridge sleeve (20) is flanged.
9. Small-bore projectile according to Claim 3,
 - the material of the jacket (5) in its front region, relative to its cylindrical region and its tail region having a thickening which is at least a factor of 2.
10. Small-bore projectile according to at least one of the preceding claims,
 - said projectile having a bore of 5.56 mm (0.223" or 0.224").
11. Small-bore projectile according to at least one of the preceding claims,
 - said projectile being lead-free.