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(71) Applicant: DELTA FRANGIBLE AMMUNITION, LLC [US/US]; 2124 Jefferson Davis Highway, Suite 301, Stafford, VA 22555-2350 (US).

(72) Inventors: DAVIS, George, B.; 4016 Buckingham Court, Dumfries, VA 22026 (US). BAINER, John, R.; 14215 Bismark Avenue, Dale City, VA 22193 (US).

(74) Agents: ROSENBERG, Sumner, C. et al.; Needle & Rosenberg, P.C., 127 Peachtree Street, N.E., Suite 1200, Atlanta, GA 30303-1811 (US).

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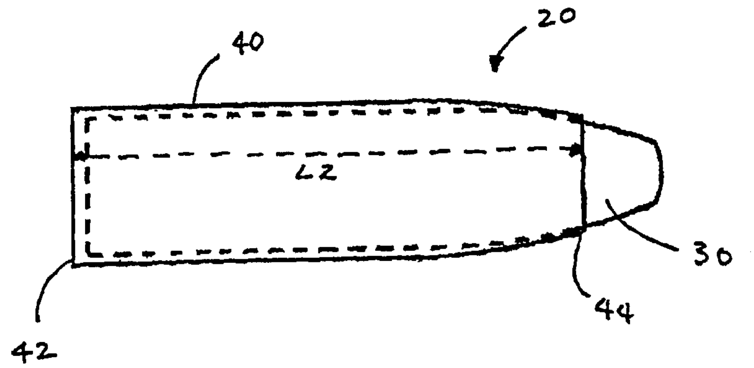

(57) Abstract

A frangible bullet (20) for use in training ranges as an alternative to live ammunition, which disintegrates upon impact with a target. The frangible bullet (20) includes an elongated frangible core member (30) fabricated from a thermosplastic polymer and at least one metal, the core member having a back end, an opposite tip end and a central portion therebetween, and having a core length between the back end and the tip end. The core member is jacketed in an outer jacket (40) having a closed first end and second end, defining a jacket chamber for complementarily receiving the core member therein. The core member fits inside the outer jacket such that the tip end of the frangible core member is exposed and impacts the target first, resulting in fragmentation of the core member and the outer jacket.

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Jacketed Frangible Bullets

RELATED U.S. APPLICATION DATA

This application claims priority to U.S. provisional application Serial No. 60/127,657 filed on April 2, 1999. The 60/127,657 provisional patent application is herein incorporated by this reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to frangible ammunition or bullets for use in training ranges as an alternative to live ammunition. More specifically, the invention relates to frangible bullets having a heavy metal loaded polymer core which is partially jacketed in a high-density high-strength material, such as copper.

Background Art

Traditionally, rifle bullets have been manufactured from lead. Lead has been a preferred material mainly because of its high density, which is beneficial for range of firing and for weapon functioning. Furthermore, because of their high ductility, lead bullets may be easily manufactured in various shapes and sizes. While lead has many characteristics beneficial to bullet manufacture, it also has drawbacks. Lead is a toxic metal that presents a health risk to the shooter from lead fumes and dust, and endangers the environment through contamination of ground water supplies.

In addition to the health and environmental issues addressed above, lead rifle bullets present additional hazards to individuals engaged in weapons training and to the range infrastructure, such as over-penetration, ricochet and backsplatter. Lead rifle bullets, particularly those used in the military, are designed to penetrate hard surfaces such as mild steel and concrete. While in a combat situation this penetration may be desirable, in training it causes costly damage to target systems and training structures.

These environmental, health, and bullet performance concerns have precipitated a number of bullet developments and innovations. New bullet designs have emerged which incorporate a variety of non-toxic material alternatives to the lead contained in standard ammunition. Included in this group are a number bullet designs utilizing heavy metal loaded polymers, generally classified as "frangible" ammunition.

Frangible bullets, which typically contain no lead, were designed to address both the physical hazards and adverse performance characteristics of lead bullets. The heavy metal loaded polymer construction of these bullets was designed to ensure consistent breakup of the bullet on impact with solid materials such as steel. These early frangible rifle bullets demonstrated a significant reduction in ricochet with a total elimination of lead toxins.

Fig. 1 shows a prior art unjacketed, one piece, polymer frangible bullet. The bullet has a cylindrical body formed with a tapered nose portion. Prior art bullets of this type are commonly manufactured by injection molding. A common composition of such prior art frangible bullets is a compounded mixture of type 11 nylon (known generally in the art as N11 nylon), copper powder and tungsten powder. A typical bullet manufactured of such a mixture in the shape depicted in Fig. 1 weighs 33 grains.

There are a number of competing design considerations at work in the construction of a frangible bullet. A primary design focus for developers of this type of bullet has always been bullet weight. Prior art bullets have been molded from a compound comprising a metal powder or combination of metal powders combined with a nylon polymer. The metal powder mixture is incorporated with the nylon polymer to provide an increased bullet weight over bullet constructions containing only nylon polymer. Of course, an increased density or ratio of metal powder to nylon in the bullet composition produces a commensurate increase in bullet weight. Bullet weights that approximate the weight of standard lead-core bullets are most conducive to proper weapon functioning. Bullet weights that approach the weight of standard bullets also improve bullet down-range accuracy by sustaining higher bullet energy levels at greater distances.

Reliable weapons functioning in most automatic and semiautomatic rifles is a result of adequate gas pressure, produced by the burning propellant in the cartridge, reaching the rifle's gas operating system. Higher gas pressure within the barrel frequently has a direct, positive effect on the reliability of weapon. Bullet weight is also relevant to reliability of weapons functioning. The cartridge, regardless of the bullet weight, produces approximately the same initial gas pressure within the barrel. The amount and type of powder utilized, not the bullet composition, dictates the initial pressure level. As the powder burns, pressure builds behind the bullet, causing the bullet to travel down the barrel of the weapon toward the gas port located near the muzzle. The pressure level rearward of the bullet as the bullet passes the gas port is critical to proper weapon functioning.

The heavier the bullet, the greater its inertia, and consequently the slower its initial velocity within the barrel. A heavier, slower moving bullet provides more time for the powder to burn, resulting in a higher pressure buildup within the barrel, and particularly at the gas port. Inversely, lighter bullets travel through the barrel at increased velocities, resulting in reduced pressure at the gas port.

One solution is to increase the ratio of metal powders to polymer until the desired bullet weight is obtained. However, the physical dimensional constraints of the bullet limit the overall bullet weight using existing metal powders and polymer materials. The physical dimensions of the rifle chamber fix the bullet's diameter and overall length. Therefore, all combinations of metal powders and polymer are constrained in overall volume by the requirement of dimensional compatibility with existing weaponry.

Other elements constraining the ratio of metal powders to polymer are the desired terminal characteristics of the bullet and the internal ballistic environment within the chamber of the weapon. The desired terminal effect of a frangible bullet is frangibility. It is desired that the bullet disintegrate as completely as possible upon impact with solid objects. Total disintegration to dust is the ultimate design objective. The degree of fragmentation is determined in part by bullet diameter and terminal velocity. Generally, the smaller the bullet diameter and higher the terminal velocity, the more complete the disintegration. In the case of heavy metal loaded polymer frangible bullets, the fragmentation or disintegration of the bullet on impact is also a function of the ratio of metals to polymer. The polymer dictates the strength of the bullet. Thus, a higher relative content of polymer produces a stronger bullet. While this consideration would appear to further support the use of higher ratios of metals in frangible bullet design, the ratio is constrained by the internal ballistic environment that the bullet must survive within the weapon.

Internal chamber pressures of automatic and semiautomatic rifles are approximately 50,000 pounds per square inch, and bullet velocities exceed 3,000 feet per second. The material strength of polymer frangible bullets must be sufficient to withstand these extreme pressures and velocities. If the ratio of metal to polymer is too high, the bullet will suffer a catastrophic, in-bore failure, which may damage the weapon and present a physical hazard to people in the proximity of the weapon. Thus, to ensure sufficient bullet strength, a minimum polymer to metals ratio must be maintained in the compound.

In addition to high chamber pressures and supersonic velocities, polymer bullets must also endure high chamber and barrel temperatures that result from automatic fire. These temperatures may exceed the melting temperature of the polymer used in the bullet's compound. Thus, if the bullet remains in the chamber too long before exiting, the polymer may soften, again resulting in a catastrophic bullet failure. This is especially the case in prior art unjacketed frangible bullet designs, in which the bullet material is exposed directly to the combustion gases which propel the bullet through the barrel.

In 1997, the Light Weapons Division of the Armament and Ammunition Testing Directorate of the U.S. Army Aberdeen Test Center, Aberdeen Proving Grounds, Maryland, published a Report of a Technical Feasibility Test of then-existing 5.56 mm and 9 mm Frangible Training Ammunition. This early government testing of unjacketed polymer ammunition documented unacceptable operational reliability for frangible rifle caliber bullets as a direct result of low chamber/gas port pressures across the spectrum of material candidates. In addition, all candidate bullets tested performed poorly in accuracy testing at ranges exceeding 50 meters. Some candidate compounds also suffered catastrophic failure due to inadequate bullet strength.

Thus, it is an object of the invention to provide a non-toxic frangible bullet which will provide the necessary bullet weight to function reliably in existing firearms. More specifically, significant demand exists for a such a frangible bullet for use in military automatic rifles and light machine guns.

It is a further object of the invention to eliminate the potential of catastrophic bullet failure by ensuring material strength and core isolation from chamber heat.

It is a further object of the invention to improve the accuracy and performance of polymer frangible bullets by increasing both bullet weight and bullet to barrel interface.

It is a further object of the invention to accomplish the above-mentioned improvements without sacrificing the reduced over-penetration, ricochet and backsplatter hazard characteristics previously demonstrated by unjacketed polymer frangible bullets.

SUMMARY OF THE INVENTION

The disadvantages of the prior art are overcome by the present invention which, in one aspect, is a frangible bullet having a core member constructed of a mixture containing a thermoplastic polymer and a lead-free heavy metal, in combination with an outer jacket. The core member has a back end, an opposite tip end, and a central portion therebetween, defining a core length between the back end and the tip end. In one embodiment, a core member having suitable strength and weight characteristics may be formed from a mixture of a type 6 nylon polymer, copper powder, and tungsten powder.

The outer jacket, which may be constructed of copper or other suitable high density, high strength metal, plastic or other polymer, has an enclosed first end and an opposite open second end defining a jacket length between its two ends. The outer jacket defines a jacket chamber for encapsulating the back end and a part of the central portion of the core member, thereby shielding the core member from the high chamber temperatures which have led to in-bore bullet failure in prior art frangible bullet embodiments. The outer jacket also forms the circumferential perimeter of the bullet of the present invention, enabling more precise control of bullet caliber than is possible in prior art designs.

The outer jacket is configured such that the nose or tip of the frangible core member is exposed. Thus, the unjacketed tip end of the core member impacts the target first. Deceleration shock on impact causes disintegration of the bullet core member, and rearward radiation of that shock ensures fragmentation of the outer jacket.

Addition of the outer jacket to the frangible core member increases the bullet's dynamic strength such that less costly, lower shear strength polymer materials may be utilized in manufacture of the core member. In addition to an increased cost-effectiveness, use of a lower shear strength polymer also ensures more complete disintegration of the core member upon bullet impact. Incorporation of the outer jacket into the bullet design also results in an increased bullet weight, which yields greater reliability and accuracy than may be obtained with prior art unjacketed frangible ammunition.

BRIEF DESCRIPTION OF THE FIGURES OF THE DRAWINGS

Fig. 1 is a side elevational view of a prior art unjacketed frangible bullet.

Fig. 2 is a perspective view of a frangible munitions cartridge according to the present invention.

Fig. 3 is a side elevational view of an embodiment of the core member of the jacketed frangible bullet according to the present invention.

Fig. 4 is a side elevational view of an embodiment of the jacketed frangible bullet according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is more particularly described in the following examples that are intended as illustrative only since numerous modifications and variations therein will be apparent to those skilled in the art. As used in the specification and in the claims, "a" can mean one or more, depending upon the context in which it is used. The preferred embodiment is now described with reference to the figures, in which like components indicate like parts throughout the figures.

As shown in Figs. 2 and 4, in one embodiment, the invention is a jacketed frangible bullet 20 having two main components, an elongated frangible core member 30 and an outer jacket 40. The embodiment pictured in Figs. 2 and 4 represents a 5.56 mm jacketed frangible bullet 20 designed for rifle use, but it should be understood that the scope of this invention extends to all calibers of bullets for use in any pistol or manual, semi-automatic or fully-automatic rifle or machine gun, or any other weapon system in which use of a frangible bullet 20 is advantageous.

Referring to Fig. 3, the core member 30 has a back end 32, an opposite tip end 34 and a central portion 36 therebetween. The length of the core member 30, or the core length L1, is defined by the distance between the back end 32 and the tip end 34. In the embodiment illustrated in Figs. 3 and 4, corresponding to a 5.56 mm rifle bullet, the core length L1 is approximately 0.8 inch.

The core member 30 is fabricated from materials including a thermoplastic polymer and at least one metal. Both type 11 and type 6 nylon materials (commonly known in the art as N11 and N6 nylons, respectively), have been successfully utilized in fabricating frangible munitions. It has been discovered that N6 nylon is preferable to N11 nylon because of its lower cost and higher specific gravity and because of its greater frangibility. N11 nylon, however, exhibits greater shear strength and bonding characteristics over N6 nylon, such that use of N11 nylon permits the use of an increased ratio of metal powder to thermoplastic polymer in the core member 30 composition.

In prior art unjacketed frangible bullet designs for 5.56 mm weapons, as shown in Fig. 1, bullet performance criteria have not been met by bullets utilizing the less expensive N6 nylon material. Thus, prior art 5.56 mm unjacketed frangible bullets have been manufactured using N11 nylon materials. As discussed in detail below, however, by the addition of an outer jacket 40 to the frangible bullet 20, dynamic strength characteristics of the bullet 20 are significantly improved, permitting the use of the less costly and lower shear strength N6 nylon material as the bonding agent for the compound. Use of the N6 nylon results in a core material more frangible than compound made with the N11 nylon.

According to the invention, other thermoplastic polymer materials in addition to those discussed above may also be utilized, including other polyamids (including other nylon formulations), polyesters and polyurethanes. Additionally, the thermoplastic polymer component may be fabricated partially or exclusively of polyvinyl chloride, fluorocarbons, linear polyethylene, polyurethane prepolymer, polystyrene, polypropylene and cellulosic and acrylic resins. It is critical, however, that the selected thermoplastic polymer utilized to form the core member 30 be highly frangible in order not to increase the terminal penetration effects of the bullet 20.

A metal component is provided in combination with the above-described thermoplastic polymer to form the core member 30. The metal component of the core member 30 includes at least one metal, and may include a combination of two or more metals as needed to achieve the desired bullet weight for the selected weapon system. Metal components are selected, in part, based upon their density and their suitability for combination with the selected thermoplastic polymer to form a completed core member 30. Because of their relatively high specific gravity, heavy metal elements have been utilized to form the metal component of the core member 30.

The metal component is commonly utilized in powder form, because of the relative ease with which powdered metals may be mixed and combined with the thermoplastic polymer material. Alternatively, metals in particulate or other forms may be utilized if they are capable of combination with the thermoplastic polymer.

In one embodiment, copper powder and tungsten powder are have been utilized to form the metal component of the core member 30. In a currently preferred embodiment, a core member 30 including N6 nylon, copper powder and tungsten powder is utilized, in relative concentrations that result in an overall core member 30 specific gravity of 6.0. This material is commercially available from Saracen Chemicals, Ltd., a United Kingdom company with offices at Vulcan House, Restmer Way, Hackbridge, Surrey, SM6 7AH, England. This material has been found to exhibit superior frangibility over a similar material containing N11 nylon, copper powder and tungsten powder having a specific gravity of 5.4. The addition of the outer jacket 40, which significantly increases the structural and thermal durability of the bullet 20, enables use of the N6 nylon core member 30, resulting in reduced cost and superior performance over the prior art.

Other metals may be utilized in the core member 30 without departing from the scope of the invention. Selected or combined heavy metals including transition metals, lanthanides and actinides provide suitable mass to the core member 30 to meet performance criteria of frangible ammunition. Because of price, availability and manufacturing concerns, four common metals have been primarily utilized in the art: zinc, tin, copper and tungsten. Any metal selected from this group may be utilized to produce frangible ammunition according to the invention.

Once the constituent materials are selected, the core member 30 may be manufactured according to methods known in the art, including injection molding.

Fig. 3 illustrates a reduced diameter, 30-grain frangible bullet core member 30 according to the present invention, compounded of a mixture of N6 nylon, copper powder and tungsten powder. The core diameter is reduced relative to unjacketed bullet core members to allow for application of the outer jacket 40 illustrated in Figs. 2 and 4 and as described in detail below.

Figs. 2 and 4 illustrate the placement of the outer jacket 40 on the frangible core member 30. Encapsulating the core member 30 in the outer jacket 40 isolates the core member 30 from direct contact with the heated chamber of the weapon, significantly reducing the potential for softening of the material and in-bore catastrophic failure of the bullet 20.

The outer jacket 40 has a closed first end 42 and an opposite opened second end 44. The jacket length L2 is the distance between the first end 42 and the second end 44 of the outer jacket 40. The hollow interior of the outer jacket 40 is referred to herein as the jacket chamber. The outer jacket 40 encloses a portion of the frangible core member 30, including the back end 32 and a portion of the central portion 36 of the core member 30, leaving at least the tip end 34 fully exposed. Installation of the outer jacket 40 over the back end 32 of the core member 30 with the tip end 34 exposed ensures that the frangible material will impact the target first. The deceleration shock generated by impact radiates rearward, ensuring the effective disintegration of the entire core member 30.

Outer jackets 40 fabricated from copper have been utilized and found acceptable for use in the present invention because of the ductility, weight and deformability of copper. Other materials may be utilized to form the outer jacket 40 without departing from the scope of the invention. For example, outer jackets 40 may be fabricated from other metals, including mild steel, guilding metal, guilding clad steel or coated tin. Alternatively, synthetic thermoplastic polymer materials may be utilized to form the outer jacket 40, provided that the selected polymer exhibits sufficient rigidity under barrel operating temperatures, without departing from the invention.

When assembled, the back end 32 of the core member 30 is inserted into the jacket chamber until the back end 32 is seated adjacent the first end 42 of the outer jacket 40. Using a dial press, a hand press or other methods known in the art, the second end 44 of the outer jacket 40 is crimped or necked-down to fixedly secure the core member 30 within the outer jacket 40. Adding this outer jacket 40 to the 30-grain core member 30 produces an overall bullet weight of 45 grains. This jacketing procedure increases the 5.56 mm bullet weight by 36 percent.

In the illustrated embodiment, the dimensions of the core member 30 and the outer jacket 40 are controlled such that the core length L1 is greater than the jacket length L2. Consequently, the tip end 34, or ogive, of the core member 30 is unjacketed and exposed to impact with targets. As discussed above, this condition has been found to promote full frangibility without significantly compromising performance of the munitions. Conversely, testing conducted with fully copper-jacketed frangible bullets has resulted in over penetration and significantly limited disintegration of the bullet.

Additionally, a lubricant may be applied to the exterior surface of the outer jacket 40 to improve weapon performance. Suitable lubricants include coatings such as Teflon, a variety of oil-based lubricants such as Militec, and a variety of powder-based lubricants such as graphite, which are known generally in the art. It should be noted that the use of some lubricants such as Teflon is restricted by various legislation currently in place.

An operational frangible munitions cartridge 50 is produced by loading the frangible bullet 20 described above into a cartridge case 52. Referring now to Fig. 2, the cartridge case 52 has a base end 54 and an opposite opened mouth end 56. The cartridge case 52 is generally hollow, defining a chamber therein which is loaded with powder and air to provide a charge.

The jacketed frangible bullet 20 is mounted within the opening defined by the mouth end 56 of the cartridge case 52 as is generally known in the art. The jacketed frangible bullet 20 protrudes from the mouth end 56 of the cartridge case 52, such that the first end 42 and a portion of the outer jacket 40 are contained within the cartridge case 52. The second end 44 of the outer jacket 40 and the remaining portion of the outer jacket 40, including the crimped or necked-down portion of the outer jacket 40 and the tip end 34 of the core member 30, protrude from the mouth end 56 of the cartridge case 52.

A primer (not shown) is provided in the base end 54 of the cartridge case 52 that detonates the charge when the weapon is fired. The sudden and substantial pressure created by the combustion of the charge within the confined chamber within the cartridge case 52 impart the forces necessary to eject the frangible bullet 20 from the cartridge case 52 and accelerate the bullet 20 to its firing speed.

The diameter of the bullet 20 illustrated in Fig. 4 is full caliber, meaning that the outside dimension of the bullet 20 conforms to the minimum and maximum outside dimensions established for this caliber bullet 20 by the Sporting Arms and Ammunition

Manufacturers Institute (SAAMI) specification. The overall length of the cartridge 50, once loaded in the cartridge case 52, also falls within those standards.

Testing Results

Testing of an unjacketed 33-grain 5.56 mm frangible cartridge described above in the discussion of the prior art provided pressure results at the chamber of 124,136 pounds per square inch and 9,695 pounds per square inch at the gas port. These results indicate that the unjacketed 33-grain bullet of the prior art was producing case pressures 8,000 to 10,000 pounds per square inch less than currently used, non-frangible military ball ammunition. More importantly, the gas port pressures for the prior art style frangible bullet were 3,000 pounds per square inch lower than the minimal acceptable value for ball ammunition. The government's Report of its Technical Feasibility Test concluded that "[t]he ramification of these differences is that weapon function may be degraded across the temperature profile since all 5.56 mm weapon systems are gas operated."

In contrast to test results from prior art unjacketed 33-grain bullet test results, testing of the heavier, copper jacketed 45-grain 5.56 mm bullet according to one embodiment of the present invention demonstrated not only improvement, but pressures and accuracy equal to or surpassing that achieved by conventional military combat ball ammunition. In side-by-side testing, the new 45-grain bullet produced chamber pressures and gas port pressures of 50,300 and 14,915 pounds per square inch respectively, while the military's issued ammunition provided pressures of 47,000 and 15,139 pounds per square inch. These improved pressures result in enhanced reliability and performance of the frangible cartridge to levels that satisfy the military's requirement.

In addition, accuracy improvements surpassed the performance of military ball ammunition at 100 meters and matched military ball's performance at 200 meters. Equally important, side-by-side comparative testing of the 33-grain unjacketed bullet and the 45-grain jacketed bullet demonstrated no measurable penetration or frangibility difference between the two cartridges.

During all testing by both the inventors and by the government, no instance of catastrophic failure of the jacketed 45-grain bullet was experienced at operating temperatures that ranged from 60 to -29 degrees C.

Although the present invention has been described with reference to specific details of certain embodiments thereof, it is not intended that such details should be regarded as limitations upon the scope of the invention except as and to the extent that they are included in the accompanying claims.

What I claim is:

1. A frangible bullet, comprising:

   a. an elongated frangible core member comprising a thermoplastic polymer and at least one metal, having a back end, an opposite tip end and a central portion therebetween, and having a core length between the back end and the tip end; and

   b. an outer jacket having a closed first end and an opposite opened second end, having a jacket length between the first end and second end, and defining a jacket chamber for complementarily receiving the core member therein,

   wherein the back end of the core member is contained within the outer jacket adjacent the first end thereof, and wherein the core length is greater than the jacket length.

2. The frangible bullet of Claim 1, wherein the metal of the core member is in powder form.

3. The frangible bullet of Claim 1, wherein the metal of the core member is in particulate form.

4. The frangible bullet of Claim 1, wherein the metal of the core member comprises a heavy metal.

5. The frangible bullet of Claim 4, wherein the core member comprises two different heavy metals.

6. The frangible bullet of Claim 5, wherein the heavy metals are copper and tungsten.

7. The frangible bullet of Claim 4, wherein the metal of the core member comprises zinc.

8. The frangible bullet of Claim 4, wherein the metal of the core member comprises copper.

9. The frangible bullet of Claim 4, wherein the metal of the core member comprises tungsten.

10. The frangible bullet of Claim 4, wherein the metal of the core member comprises tin.

11. The frangible bullet of Claim 1, wherein the outer jacket is constructed of copper.

12. The frangible bullet of Claim 1, wherein the outer jacket further comprises a jacket exterior surface extending between the first end and the second end, the exterior surface being coated with a lubricant.

13. The frangible bullet of Claim 1, wherein the thermoplastic polymer comprises a polyamid.

14. The frangible bullet of Claim 1, wherein the thermoplastic polymer comprises a polyurethane.

15. The frangible bullet of Claim 1, wherein the thermoplastic polymer comprises a polyester.

16. The frangible bullet of Claim 13, wherein the polyamid comprises Type 6 Nylon.

17. The frangible bullet of Claim 13, wherein the polyamid comprises Type 11 Nylon.

18. The frangible bullet of Claim 1, wherein the core member comprises Type 6 Nylon, copper powder and tungsten powder.

19. The frangible bullet of Claim 18, wherein the core member has a specific gravity greater than 5.4.

20. The frangible bullet of Claim 18, wherein the core member has a specific gravity substantially equal to 6.0.

21. A frangible munitions cartridge, comprising:

   a. a cartridge case having a base end with a primer disposed therein and an opposite opened mouth end, the cartridge case defining a chamber between the two ends and containing a charge therein;

   b. a frangible bullet mounted within the opening defined by the mouth end of the cartridge case, the frangible bullet comprising: an elongated frangible core member comprising a thermoplastic polymer and at least one metal, having a back end, an opposite tip end and a central portion therebetween, and having a core length between the back end and the tip end; and an outer jacket having a closed first end and an opposite opened second end, having a jacket length between the first end and second end, and defining a jacket chamber for complementarily receiving the core member therein, wherein the back end of the core member is contained within the outer jacket adjacent the first end thereof, and wherein the core length is greater than the jacket length.

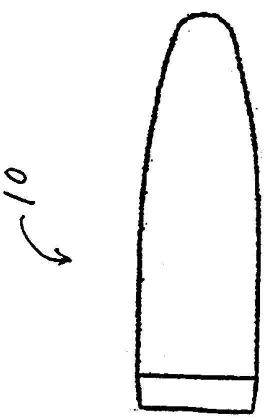
22. A method of forming a frangible bullet, comprising:

a. providing an elongated frangible core member comprising a thermoplastic polymer and at least one metal, having a back end, an opposite tip end and a central portion therebetween, and having a core length between the back end and the tip end;

b. providing an outer jacket having a closed first end and an opposite opened second end, having a jacket length between the first end and second end, and defining a jacket chamber for complementarily receiving the core member therein;

c. inserting the core member into the jacket chamber so that the back end of the core member is adjacent the first end of the outer jacket; and

d. crimping the outer jacket adjacent the second end to fixedly secure the core member within the outer jacket.



PRIOR ART

Figure 1

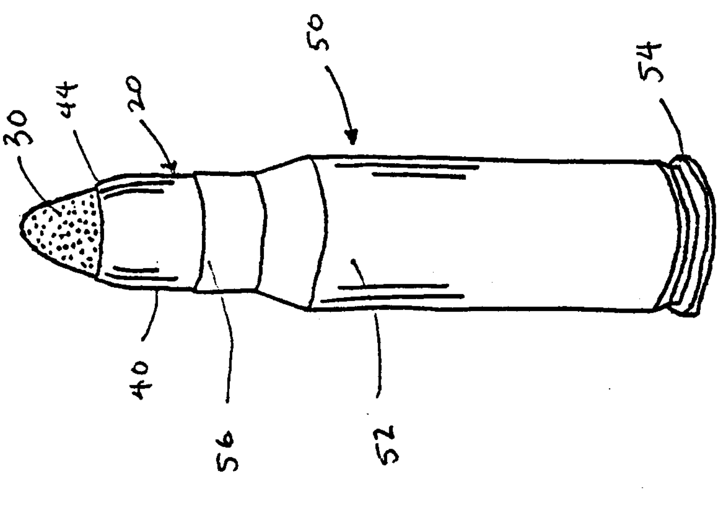


Figure 2

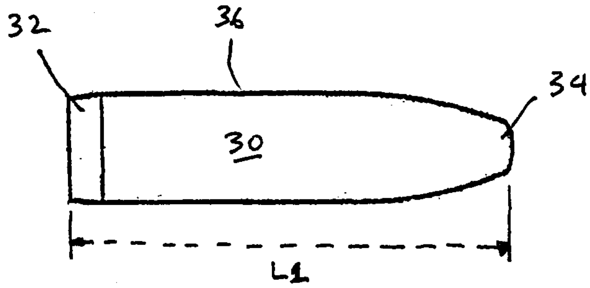


Figure 3

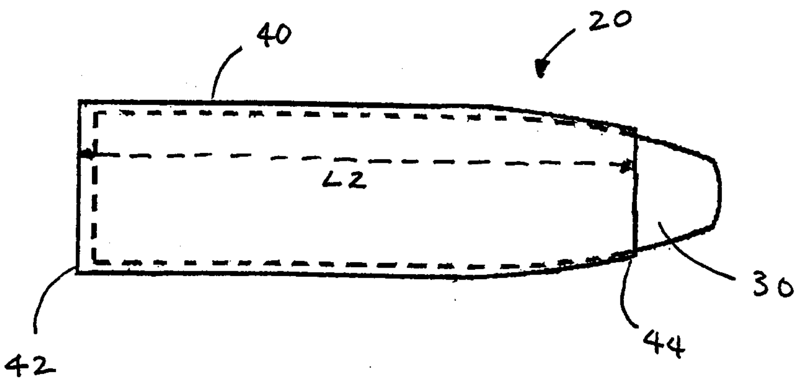


Figure 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/08702

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :F42B 12/74
US CL :102/516
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : US 102/501, 506-511, 514-517, 529

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	EP 578,981 A (METALLWERK ELISENUETTE GMBH) 19 JANUARY 1994 (19/01/94), FIG. 2, LINES 3-15 OF COL. 2.	1, 2, 4, 8, 21 ---------- 3, 5-7, 9-20, 22
Y	US 3,326,133 A (STADLER ET AL) 20 JUNE 1967 (20/06/67), LINES 56-63 OF COL. 1.	3
Y	US 5,616,642 A (WEST ET AL) 01 APRIL 1997 (01/04/97), ABSTRACT.	5, 6, 9, 18
Y	US 2,995,090 A (DABENSPECK) 08 AUGUST 1961 (08/08/61), LINES 40-70 COL. 6.	7, 16, 18
Y	US 5,814,759 A (MRAVIC ET AL) 29 SEPTEMBER 1998 (29/09/98), LINES 15-31 OF COL. 2.	10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"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)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 JULY 2000	25 AUG 2000

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
HAROLD TUDOR
Telephone No. (703) 306-4172

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/08702

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,349,907 A (PETROVICH ET AL) 27 SEPTEMBER 1994 (27/09/94), LINES 2-7 OF COL. 2.	11
Y	US 5,062,974 A (VAN METER) 05 NOVEMBER 1991 (05/11/91), ABSTRACT.	12
Y	US 5,237,930 A (BELANGER ET AL) 24 AUGUST 1993 (24/08/93) ENTIRE DOCUMENT.	13, 17, 19, 20
Y	US 3,123,003 A (LANGE, JR. ET AL) 03 MARCH 1964 (03/03/64) LINE 71 OF COL. 2, THROUGH LINE 3 OF COL. 3.	14, 15
Y	GB 1,007,227 A (GEVELOT) 13 OCTOBER 1965 (13/10/65), LINES 39-41 OF PAGE 1.	22
A	US 5,767,438 A (LANG ET AL) 16 JUNE 1998 (16/06/98).	