United States Patent [19]

Wasserman et al.

[11] **3,880,083**

[45] **Apr. 29, 1975**

[54] **BIMETALLIC MASS STABILIZED FLECHETTE**

[75] Inventors: **Saul Wasserman,** Rockaway, N.J.; **Robert S. Salzman,** Manhattan, N.Y.; **Walter C. O'Keefe,** Landing, N.J.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

[22] Filed: **May 19, 1967**

[21] Appl. No.: **642,648**

[52] **U.S. Cl.** **102/92.4;** 102/DIG. 7

[51] **Int. Cl.** **F42b 11/02**

[58] **Field of Search** 102/38, 41, 92.3, 92.4, 102/DIG. 7

[56] **References Cited**

UNITED STATES PATENTS

34,285	1/1862	Mefford	102/92.4
1,178,516	4/1916	Hardcastle	102/DIG. 7
2,433,334	12/1947	Birkeland	102/92.3 X
2,482,132	9/1949	Studler et al.	102/92.3 X
3,344,711	10/1967	Mawhinney et al.	102/DIG. 7

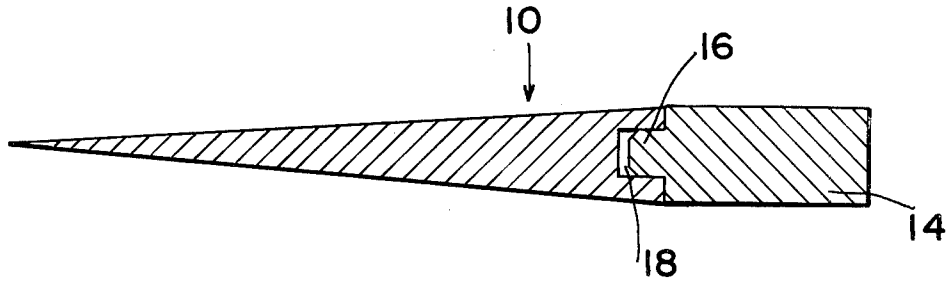
Primary Examiner—Robert F. Stahl

Attorney, Agent, or Firm—Nathan Edelberg; Robert P. Gibson; Vincent W. Cleary

[57] **ABSTRACT**

A mass stabilized flechette including a forward solid cone-shaped portion comprising most of the total weight of the flechette, made of a relatively heavy alloy, and a rearward solid body portion made of a relatively light material such as aluminum, beryllium or the like.

9 Claims, 6 Drawing Figures



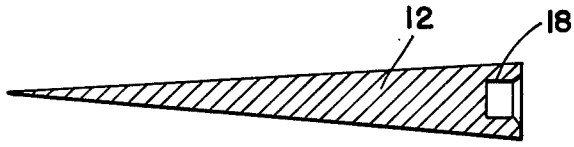


FIG. 1.

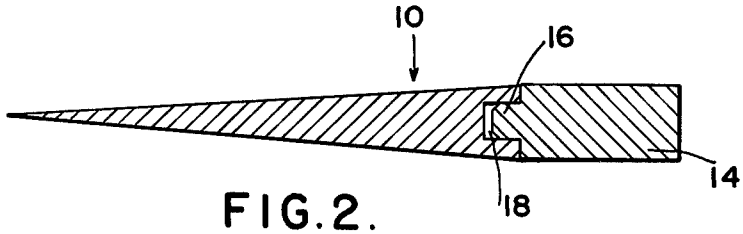


FIG. 2.

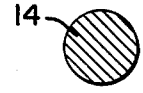


FIG. 5

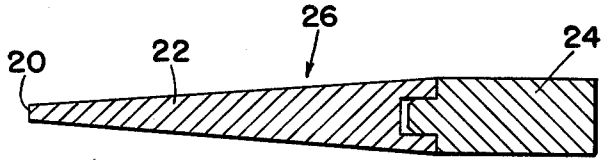


FIG. 3.

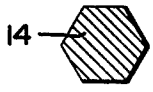


FIG. 6

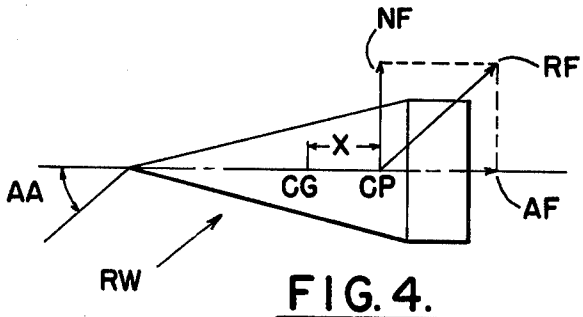


FIG. 4.

Inventors
SAUL WASSERMAN
ROBERT S. SALZMAN
WALTER C. O'KEEFE

By Harry M. Saragovitz,
Edward J. Kelly, Herbert Berl
& A. Dubroff
Attorneys

BIMETALLIC MASS STABILIZED FLECHETTE

The invention relates to a mass stabilized flechette and more particularly to a bimetallic mass stabilized flechette.

Prior art flechette designs were either fin stabilized or aft flare stabilized. Both the fins and the aft flare, each located at the rear of their respective flechettes, have an aerodynamic force acting on them which must compensate for the force acting on the nose of the flechette. When the resultant action point for these forces is located behind the center of gravity, the flechette has aerodynamic static stability.

Conventional fin stabilized flechettes have been launched by explosive means, but the ejective forces and therefore the launch velocities, had to be held low to prevent damage to the fins. The novel mass stabilized flechette, to be described below, since it has no fins, can withstand higher explosive forces without sustaining damage and therefore can be launched at higher velocities than the fin stabilized flechette. Conventional aft flare stabilized flechettes can be explosively launched without sustaining damage, but, due to the high drag of the flare, have a quicker velocity decay than the novel mass stabilized flechettes. The velocity decay is a function of the ballistic coefficient of the flechette.

$$\text{Ballistic coefficient} = \frac{\text{weight}}{(\text{drag coefficient})(\text{diameter})^2}$$

The larger the ballistic coefficient, the smaller the velocity decay will be over the same increment of time. Therefore, given a fixed weight and diameter, the only way to improve the ballistic coefficient is to design the flechette shape to have the lowest drag coefficient possible within the limits of the design criteria, hence, the invention.

Denser packing of a multiplicity of flechettes is possible due to the aerodynamic exterior shape of the inventive flechette. The body portion of the flechette can be cylindrical or can be made hexagonal in shape to further increase the packing density without changine its superior aerodynamic characteristics. On fin and aft flare stabilized conventional flechettes, the presence of fins and body flares prevents dense packing.

This invention is superior to existing flechette designs by possessing the following characteristics:

1. Ability to withstand without damage the forces of explosive ejection necessary for launching at the velocity required for lethality;

2. Superior flight and terminal ballistics producing zero yaw and low coefficient of drag;

3. Capability of high density packing;

4. Increased penetrability due to a nose of uranium alloy 111½ which has yield strengths in the range of 100,000–300,000 PSI and hardness on the Rockwell C scale between 39 and 55.

If flechettes of various weights are considered, velocity is not the only parameter which determines lethality. However, if the flechette weight is held fixed, velocity is the major factor since lethality is a function of the kinetic energy.

$$KE = \tfrac{1}{2}(\text{Mass})(\text{velocity})^2$$

Therefore, the higher the velocity the greater the kinetic energy. The greater the KE, the more capability the flechette has to penetrate and kill a target.

Yawing motion, as above mentioned, is the angular motion of the flechette about its own center of gravity in reference to the flight path traced by the center of gravity. Yaw angle is defined as the angle between the longitudinal axis of the flechette and the tangent line to the trajectory. Drag is defined as the retarding force exerted on the flechette by the air flow. The lowest drag force occurs when the orientation of the flechette with respect to the air flow is at 0° angle of attack. This is due to the fact that the smallest cross sectional area is presented to the air flow when the flechette is in this orientation. Therefore, it is desirable to have the flechette remain at a 0° angle of attack in order to keep the velocity drag decay to a minimum.

It is therefore an object of the present invention to provide a mass stabilized flechette which eliminates the undesirable feature of the above mentioned factors.

Another object is the provision of a mass stabilized flechette which can fly at a zero angle of attack and have a low draw coefficient.

Still another object is to provide a mass stabilized flechette having superior penetration capability upon impact.

A further object is the provision of a mass stabilized flechette which can be densely packed with other similar flechettes.

The above objects as well as others together with the benefits and advantages of the invention will be apparent upon reference to the detailed description set forth below, particularly when taken in conjunction with the drawing annexed hereto in which:

FIG. 1 shows the cone portion of the flechette.

FIG. 2 shows the cone portion as attached to the body portion of the flechette.

FIG. 3 illustrates an embodiment of the present invention.

FIG. 4 is a diagrammatic showing of the invention.

FIG. 5 is a cross sectional view of the body portion of the flechette showing the body portion to be circular.

FIG. 6 is a cross sectional view of the body portion of an embodiment of the flechette showing the body portion to be hexagonal.

The cone portion **12** is made of an uranium alloy and the body portion **14** is made of either high strength aluminum or beryllium. Body portion **14** which may be circular or hexagonal in cross section, FIGS. **5** and **6** respectively, has a constant length of 2.77 calibers, which in conjunction with cone **12** gives the most rearward aerodynamic center of pressure. The amount of stability a mass stabilized flechette has is determined by how far the aerodynamic center of pressure is behind the center of gravity. The larger the separation, the more stable the flechette. Therefore, the most desirable center of pressure is the most rearward aerodynamic center of pressure that can be obtained. The dimensions of cone **12** have been selected to obtain the desired flechette weight. A diameter has been chosen such that cone **12** possesses about 86% of the total weight of flechette **10.**

Assembly of the flechette **10** is accomplished by the mating of body portion member **16** and the hollow

cone receptacle **18** and the bonding thereof with epoxy (Epon VIII). A 89.7 grain uranium-aluminum or an 85.4 grain uranium-beryllium flechette design is shown in FIGS. **1** and **2,** but scaling down will produce stable flechettes in weights as low as 20 grains.

Uranium alloy 111½ was selected as the material for cone **12** due to the fact that it was developed expressly for projectiles. Its composition consists of 1% Molybdenum, 1% Zirconium, 1% Columbium, 0.5% Titanium and 96.5% Uranium (depleted).

Uranium alloy 111½ has superior penetrating capabilities and also the high density necessary to maintain the center of gravity of the flechette forward of the aerodynamic center of pressure.

The beryllium or aluminum employed in the body portion **14** has the high strength and rigidity necessary to withstand the shock of explosive ejection. The aerodynamic stability of the flechette also requires the low density of beryllium or aluminum.

An alternate design, as seen in FIG. **3,** could possess a slightly blunted nose **20** of cone **22.** The cone **22** is attached to body portion **24** of flechette **26** in a manner similar to FIGS. **1** and **2.** This design would provide still greater penetration.

The scientific principal involved in the aerodynamic mass stabilization of this invention, as seen in FIG. **4,** requires the proper location of the aerodynamic center of pressure, CP, with respect to the center of gravity, CG, of the flechette. The location of the CG forward of the CP is the requirement necessary for stability. FIG. **4** shows the angle of attack AA, the relative direction of the wind RW, the normal force NF, the axial force AF, and the resultant force RF. It can readily be seen that the normal force NF times the distance between the center of gravity CG and the center of pressure CP equals the restoring moment of the flechette.

As would be applicable for explosive warhead ejection, these flechettes would be packed in a dense matrix of woods metal, which is a low melting alloy (158±F) composed of approximately:

Bismuth	50%
Lead	25%
Cadmium	13%
Tin	12%

launched by high explosives and buffered with a 2 inch layer of styrofoam. The buffering and matrix materials are designed to transform and attenuate peak shock waves. This attenuation provides a more efficient energy transfer from explosive to flechettes because it reduces the effects of explosive shock by leveling out the energy pulse providing for a smooth transfer of energy. This is similar to a spring acting to reduce the effect of shock loads. A wave shaping device, which causes the shock wave to take the form of a plane which is oriented such that it imparts its energy to the flechettes normal to their longitudinal axis, may be employed to further the proper transfer of explosive energies. After explosive impact, the matrix material breaks loose of the flechettes, thus allowing them to fly independently to the target.

Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood, that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

We claim:

1. A mass stabilized flechette for employment in warheads and explosive launch ejection systems comprising

a forward solid cone-shaped portion comprised of a base and nose portion,

said base portion defining a hollow receptacle,

a rearward solid body portion having a forward and rearward end,

said forward end having an integral member which is axially aligned with and adapted to be inserted and secured in said hollow receptacle,

said cone-shaped portion comprising about 86% of the total weight of the flechette,

said body portion being 2.77 calibers in length which in conjunction with said cone-shaped portion results in a rearward aerodynamic center of pressure.

2. A flechette of the type described in claim **1** wherein said cone-shaped portion is made of a high density material to provide the center of gravity forward of the aerodynamic center of pressure.

3. A flechette of the type described in claim **2** wherein said cone portion is made of an uranium alloy.

4. A flechette of the type described in claim **1** wherein said body portion is made of a low density high strength material to provide aerodynamic stability and to be able to withstand the shock of explosive ejection.

5. A flechette of the type described in claim **4** wherein said body portion is made of a material selected from the group consisting of aluminum and beryllium.

6. A flechette of the type described in claim **1** wherein the cross sectional shape of the body portion is hexagonal.

7. A flechette of the type described in claim **1** wherein said cone has a blunted nose.

8. A flechette of the type described in claim **1** wherein said cone portion and body portion are bonded together in axial alignment with an epoxy.

9. A flechette of the type described in claim **1** wherein the cross sectional shape of the body portion is circular.

* * * * *