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[54] **UNDERWATER PROJECTILE**

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Related U.S. Application Data

[63] Continuation of Ser. No. 734,291, June 4, 1968, abandoned.

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[51] **Int. Cl.**^{2} **F42B 11/00**

[58] **Field of Search** 102/48, 92.1; 114/20

[56] **References Cited**

UNITED STATES PATENTS

3,434,425 3/1969 Critcher 114/20

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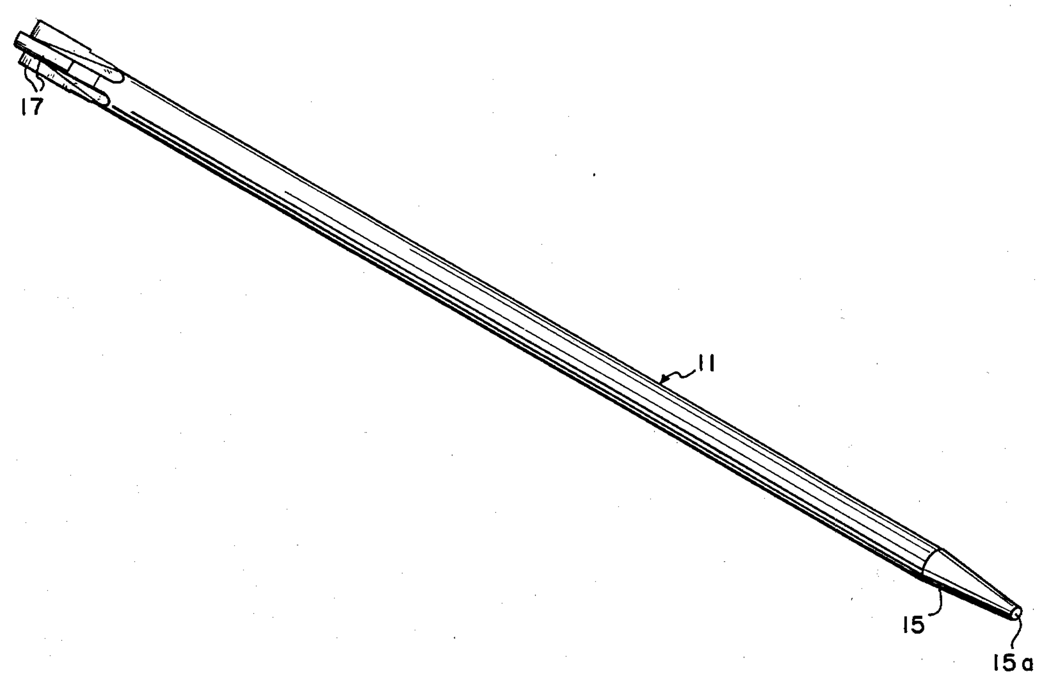
[57] **ABSTRACT**

An efficient underwater projectile is disclosed having a frustoconical nose end, a long thin shank and a shroudless, stepped parallel side wall finned rear section with a forward facing abrupt shoulder formed thereon between two parallel longitudinal edge surfaces, the forward edge surface terminating at a sloped edge surface connecting with the shank, and the fins being joined at the shank body by a rearwardly tapered body section with triangular tapered and rearwardly inwardly sloping outer separation surfaces between the fins.

14 Claims, 5 Drawing Figures



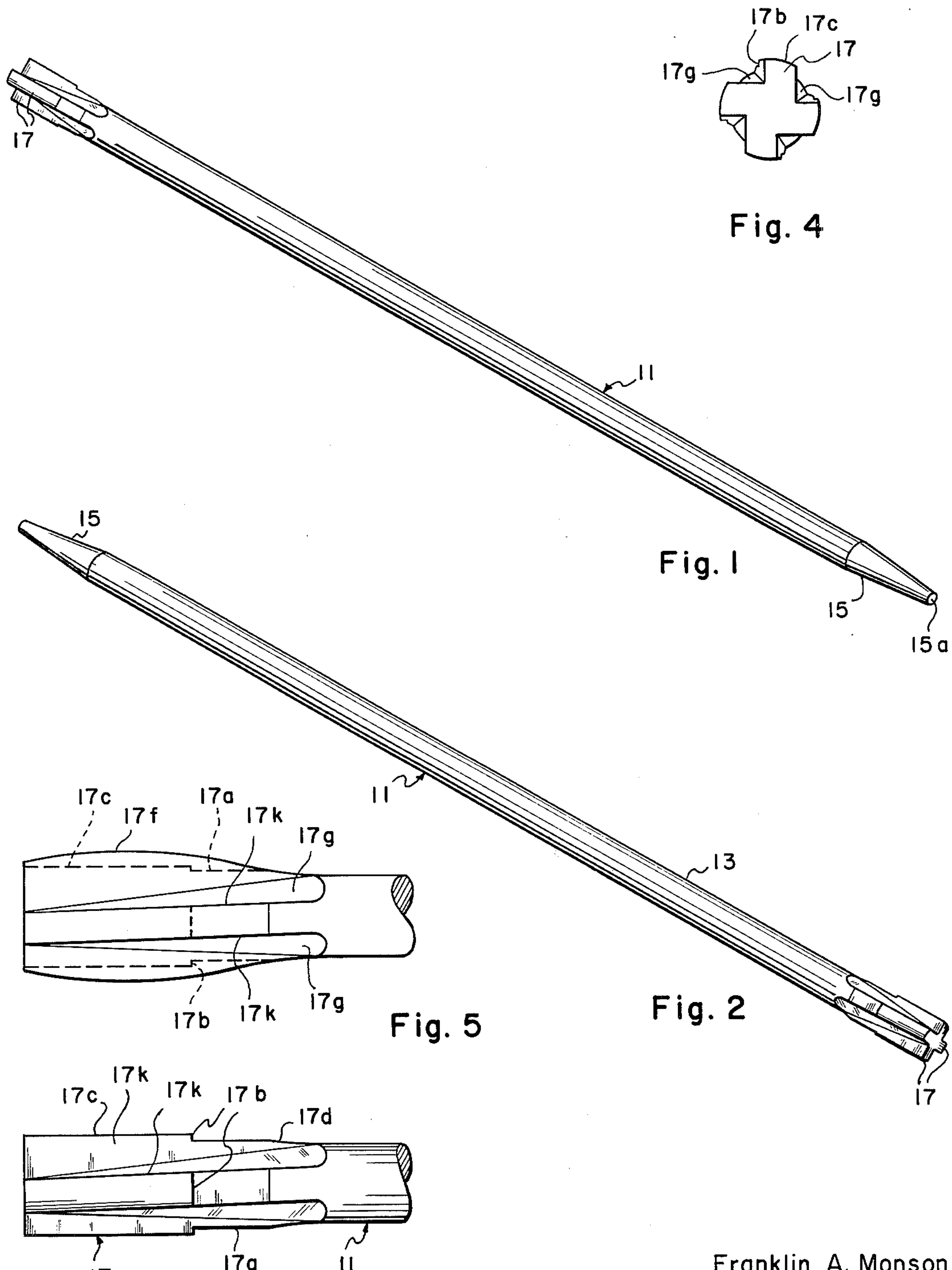


Fig. 4

Fig. 1

Fig. 2

Fig. 5

Fig. 3

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UNDERWATER PROJECTILE

This is a continuation of Ser. No. 734,291 filed June 4, 1968, now abandoned.

This invention relates to underwater projectiles, and particularly to an improved underwater projectile flechette type incorporating a particular configuration which maximizes velocity, range and target penetration, particularly in the range of depths of up to 90 feet and the underwater visibility range at depths up to 30 feet.

In the prior art, various projectile arrangements have been employed for underwater ammunition, the most common being spear gun projectiles and shot shell power heads, as well as combined shot shell and spear projectiles. Such prior configurations have been substantially less than fully effective, due to such deficiencies as cumbersome size, limited velocity, limited effective range and small terminal energy for target penetration.

It is an object and feature of this invention to provide an underwater projectile of superior velocity, range and target penetration in water depths of up to 90 feet and at ranges extending up to the effective visibility range at these depths.

Still other objects, features and attendant advantages will become apparent to one skilled in the art from a reading of the following detailed description of a single preferred embodiment constructed according to the invention, taken in conjunction with the accompanying drawings wherein:

FIGS. **1** and **2** are perspective views of a flechette projectile according to the invention.

FIG. **3** is fragmentary longitudinal side view of the rear section projectile of FIGS. **1** and **2**, showing its stabilizing fin construction.

FIG. **4** is a rear end view of the underwater projectile of FIGS. **1** and **2**.

FIG. **5** is a view of the projectile during manufacture, and showing the fins in full line prior to final formation, and the broken line in the final configuration of FIG. **3**.

Referring now in detail to the Figures of the drawings, the projectile **11** includes a cylindrical shaft or shank **13** having a frusto-conical nose section **15** with a flat tip end **15***a*, and a stabilizing tail section including canted stabilizing fins **17** each having parallel opposite side walls **17***k*, **17***k*.

The overall length B of the fins **17** is approximately four shaft diameters and the overall length A of the frusto-conical nose section **15** is approximately three and one-half shaft diameters.

The four stabilizing radial fins **17** are integrally formed with the shank **13**, as by hot or cold metal working of the shank body to form the desired configuration, as through the medium of a suitable forming die, to an initial configuration as shown in full lines in FIG. **5**, with the curved outer edge **17***f* of the fins resulting from the amount of material disposed from the shank cylindrical blank into the fin formations when the die is pressed in to form the substantially flat or concave triangular rearwardly and inwardly tapered connecting surfaces **17***g* between the fins **17***t*. Surface grinding of the radially outer surface of the fins is employed to effect the desired intermediate and rearward radial surface final configuration as shown at **17***a*, **17***b*, **17***c* in FIGS. **3** and **5**. Each of the respective parallel-walled fins is preferably canted at an angle of approximately 2° with respect to the longitudinal axis of the shank **13**. It will be appreciated that the canted fins **17** contribute to trajectory accuracy by imparting spin to the projectile, whereby for a given yaw angle the canted fin projectile dispersion is helical and has a smaller radius of error dispersion than that which would be obtained by a straight finned configuration with a unidirectional dispersion. The fins **17** are formed by the initial die forming step with an inclined forward face **17***d*. The intermediate forward reduced span or diameter section having a radially outer surface **17***a* of substantially constant diameter and the enlarged span or diameter rear section having its radially outer surface **17***c* also of substantially constant span along its length are initially die formed and then surface ground as discussed above. At the longitudinal junction of reduced span section **17***a* and enlarged diameter rear section **17***c* of each fin is radially extending forwardly facing flat surfaced shoulder **17***b* which is also formed by surface grinding, preferably during the grinding of the radially outer surfaces **17***a* and **17***c*. The diameter of the larger diameter rear constant diameter surface **17***c* substantially equal to approximately one and one-fourth to one and two-fifths diameters of the shaft or shank **13**, and the smaller diameter intermediate surface is approximately one and one-tenth to one and one-fifth shank diameters, the depth of the shoulder **17***b* being approximately one-tenth to one-fifth shank diameters.

The cone angle of the frusto-conical nose section **15** is **10**° (±**1**°), included, and the flat tip end **15***a* of the frustum is approximately 0.30 to 0.35 of the diameter of the shaft or shank **13**.

The overall length of the projectile is equal to between 30 and 43 shaft diameters, with a preferred length of 43 diameters for minimum desired muzzle velocity of approximately 700 to 750 feet per second and associated launching propellant chamber pressures.

In one illustrative and preferred embodiment in which the shaft diameter is 0.100 inch, the shoulder has a depth of 0.010 inch, and the outer diameter of the rear fin surface **17***c* is 0.131 inch. Also, in this particular preferred embodiment, the projectile shank **13** is formed of tungsten, the overall weight being 150 grains, and the overall length being 4.3 inches, with a frustrum cone angle of 10° and a tip diameter of 0.030 inches.

In operation, the launching velocity of the projectile is preferably near that of atmospheric pistol ammunition, being approximately 700 to 750 feet per second, and whereas drag forces render atmospheric bullet shapes and other flechette shapes ineffective in very short ranges under water, the present projectile is far superior in its range capability under water. The high mass per frontal area and specific nose and tail proportions contribute mutually to an efficiently low coefficient of drag, and the stability of the projectile flight is also maximized by the same balance of proportions.

Prior copending application Ser. No. 650,374 filed June 30, 1967, now U.S. Pat. No. 3,434,425, illustrates an ammunition arrangement through the medium of which similar, but shroudless shouldered finned underwater projectile is launched. A similar ammunition arrangement may be employed for launching the shroudless, shouldered finned underwater projectile according to the present invention.

In operation, as the projectile flies through the water the flat frustrum tip area **15***a* separates a bulk of water normal to the trajectory, creating a cavitation envelope of specific shape and length relative to the instant projectile velocity and depth. The instantaneous cavitation envelope for velocities up to approximately 700 feet per second and depths up to 90 feet has an effective length extending well back of the rear finned section **17** of the projectile **11**, and may be of a length up to several times the projectile length, dependent upon depth and instant velocity, before pressure can close the cavity. The cavity is difficult to precisely measure and define in structural contents; however, evidence indicates that the forward area of the envelope surrounding the projectile body is composed of water vapor of varying density levels, the density gradient increasing at a high rate of change from the zone immediately adjacent the projectile body to the zone at the edge of the cavitation envelope, and the lines of equal vapor density extending in something of an arcuate form from the zone of the flat tip **15***a* in a generally convex form along the length of the projectile and the remainder of the envelope rearwardly to the zone of closure where larger water droplets are forced into the envelope zone. It has been found that the density gradient of the water vapor increases so rapidly from the zone adjacent the projectile body that small increases of tail fin diameter or projectile length, with respect to shaft diameter, cause very large increases in drag with resultant decrease in velocity and effective range and terminal energy of the projectile. The tail configuration **17** raises a stabilizing force from collision with the vapor within the cavitation envelope, and as the water vapor thus exerts a drag force on the tail section at the same time, it will be appreciated that the tail section must be formed with the concept of minimizing contact with vapor while insuring sufficient stabilizing force to accomplish stability or projectile flight. With the foregoing mentioned configuration and relative dimensions and weights, for muzzle velocities of approximately 700 feet per second and depths up to 90 feet, the projectile is nearly free of boundary layer drag forces over its effective range except for the area of the frustrum flap tip end **15***a*, and the very minute drag force exerted on the tail section **17** by the low density water vapor in the central zone of the cavitation envelope cross section. The area of the flat tip end **15***a* is optimized for minimum drag and desired cavitational envelope vapor impingement for stability control on the tail section **17**, a frustrum tip end **15***a* of smaller proportion producing erratic flight with severe jaw resulting in negligible effective range, whereas increase in the proportions of the flat tip end **15***a* results in higher drag forces at this zone, which also decreases the effective range. In addition, it has been found that increases in the cone angle of the nose section **15**, and/or the outer diameter of the fins **17** also results in higher drag forces which decrease the effective range, as will be apparent from considerations of the rapid radial increase in vapor density of the water vapor within the cavitation envelope. While use of a shroud as disclosed in application Ser. No. 650,374 now U.S. Pat. No. 3,434,425, effectively minimizes yawing and increases flight accuracy of the projectile the shroud also reduces velocity materially more than the present invention, particularly due to the inherently larger frontal and surface area of the shroud and the drag resulting from axially vectored impingement of the water vapor particles on the large frontal and outer surface area. The present intermediate shoulders **17***b* between the two constant diameter surfaces **17***a*, **17***c* on the fins **17** have surprisingly been found to be substantially equivalent in reducing and have resulted in further increased accuracy, apparently due largely to the materially less drag, and higher terminal velocities or longer effective range for a given initial velocity than that of the prior shrouded finned projectile. Further, while the shrouded projectile of U.S. Pat. No. 3,434,425 is quite satisfactory in shallow depths, this shrouded projectile has inadvertently decreased accuracy as water depth increases, and the present shroudless stepped shouldered finned projectile has been found to afford materially better accuracy at increased depths' than the shrouded projectile, due to its decreased drag and higher terimal velocities at such depth, as compared to prior shrouded finned projectile.

It has further been found that reduction of the overall length relative to diameter and tip end area results in less momentum with proportionate loss in effective range, unless the launching velocity is increased inversely proportionate to the length reduction. In this respect, the preferred length of the overall projectile **11** has been found to be 43 diameters, and by a sacrifice of higher launching velocities and associated higher chamber pressures the length of the projectile has been successfully varied down to a length of 30 shaft diameters. It will, of course, be appreciated that such requirement for higher launching velocities and associated higher firing chamber pressures for launching the projectile put severe requirements upon the weight and strength of the launching ammunition arrangement and/or barrel with consequent increase in bulkiness and the weight of the equipment and decrease in efficiency of power utilization.

It has been found that the terminal efficiency of the remaining energy when the projectile is at a 30 foot range, which is the general visibility range in shallow water of up to 3 foot depth, equals normally better than approximately one-half that of the energy of the projectile at the launch location, and produces penetration force concentration of an extreme degree over a distance equal to and beyond this 30 foot visibility range. At the 90 foot depth the terminal efficiency of the remaining energy is about 25% of that of the launch location energy of the projectile, with consequent lesser but effective penetration force.

It will accordingly be appreciated that the critical interrelation of the various parameters of the projectile are effective overall to provide a highly desirable and useful underwater projectile which may be effectively used by underwater fishermen, divers, etc., with good results within the operating ranges of visibility in water depths up to 90 feet, and using launching velocities conventional to atmospheric piston ammunition in the vicinity of 700 feet per second.

While the invention has been described with respect to a single illustrative and preferred embodiment, it will be apparent to those skilled in the art that various modifications may be made without departing from the scope and spirit of the invention. Accordingly it is to be understood that the invention is not to be limited by the illustrative embodiment, but only by the scope of the appended Claims.

That which is claimed is:

1. An underwater projectile comprising:

a long thin shaft having a cylindrical shank section, a frusto-conical forward nose section, and a finned tail section,

said frusto-conical nose section having a blunt tip end with a diameter substantially one-third of the shank diameter for forming a drag-reducing cavitation envelope longer than said projectile during passage of said projectile through water,

said tail section being shroudless and having a plurality of radial fins formed thereon,

each of said fins having effectively water-engageably exposed spaced apart discrete forward and rearward radially outer longitudinally extending edge surfaces separated by a radially extending forwardly facing steeply inclined effectively water-engageably exposed shoulder formed intermediate the length of each respective said fin, and thereby forming a forwardly and radially water-engageably exposed mid-length step.

2. An underwater projectile according to claim **1**, said fins each having substantially smaller sloped surfaces forward and rearward of said shoulder and materially longer than the radial depth of said shoulder.

3. An underwater projectile according to claim **2**, said smaller sloped surfaces being of substantially zero slope and constant diameter, and said shoulder being substantially normal to the axis of said projectile.

4. An underwater projectile according to claim **3**, and a forwardly radially inwardly sloping outer edge surface formed forward of the forwardmost end of said substantially constant diameter surface on each of said fins and connecting with said cylindrical shank section.

5. An underwater projectile according to claim **4**, the angle of inclination of the conical surface of said conical nose section being in the range of approximately 9°–11°, and said blunt tip end being flat.

6. An underwater projectile according to claim **5**, said nose cone angle being substantially 10°.

7. An underwater projectile according to claim **6**,

said shaft having a length of between approximately 30 and 43 shank diameters.

8. An underwater projectile according to claim **6**, said shaft having a length of substantially 43 shank diameters.

9. An underwater projectile according to claim **7**, said fins having a length of approximately four shank diameters,

said fins having their rearmost constant outer diameter equal to approximately 1-1/5 to 1-2/5 shank diameters and their forwardmost constant diameter surfaces equal to approximately 1-1/10 to 1-1/5 shank diameters.

10. An underwater projectile according to claim **7**, said fins having a rear diameter of approximately 1-1/3 shank diameters, with a shoulder depth of approximately 1/10 shank diameter.

11. An underwater projectile according to claim **1**, each of said fins having a two-stepped radially outer edge surface extending parallel with the axis of said shaft, with said extending said shoulder being contiguous with and connecting between said edge surface and extending normal to said shank axis.

12. An underwater projectile according to claim **11**, said fins being canted at an angle of approximately 2° to the shaft axis,

said shoulder being disposed approximately midway between the forward and rear ends of said fins.

13. An underwater projectile according to claim **11**, said fins each having substantially planar parallel side wall surfaces.

14. An underwater projectile according to claim **13**, and interconnecting rearwardly and laterally inwardly tapered surfaces formed and connecting between said fins, the forwardmost end of said tapered surfaces being forwardly arcuately convex.

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