

**Title: Shell Accelerator****FIELD AND BACKGROUND OF THE INVENTION**

The present invention relates to projectiles and, in particular, it concerns a projectile such as a bomb which includes a shell fired from a gun barrel.

Various projectiles have been suggested for boosting the speed of at least part of a projectile beyond the normal terminal speed or closing speed of the projectile body. Most commonly, a velocity boost is provided by a rocket motor which accelerates a payload towards a target. An example of such a device may be found in US patent no. 6540175.

Rocket motors typically require burn times of several tens of milliseconds in order to achieve their maximum velocity. A terminal-phase booster rocket must therefore be ignited at a relatively large altitude (distance to the target). The extended flight of the payload after actuation of the rocket motor may lead to problems of lack of accuracy and/or change of attack angle relative to the original path of the main projectile.

**SUMMARY OF THE INVENTION**

The present invention is a projectile such as a bomb which includes a shell fired from a gun barrel.

According to the teachings of an embodiment of the present invention there is provided, a projectile selected from the group comprising: a bomb and a missile, the projectile comprising: (a) a housing configured to travel stably through the air; (b) a gun barrel deployed within the housing; (c) a shell

deployed within the gun barrel, the shell containing an explosive charge; and  
(d) a quantity of black powder or other low-explosive deployed for firing the  
shell from the gun barrel.

According to a further feature of an embodiment of the present  
5 invention, the housing has a central axis, and the gun barrel is aligned with, or  
parallel to, the central axis.

According to a further feature of an embodiment of the present  
invention, the housing has an outer diameter, and wherein the gun barrel has an  
inner diameter at least half of the housing outer diameter.

10 According to a further feature of an embodiment of the present  
invention, the black powder or other low-explosive is configured to have a  
burn-time of not more than 10 milliseconds.

According to a further feature of an embodiment of the present  
invention, the black powder or other low-explosive is configured to generate a  
15 pressure within the gun barrel of at least 1000 atmospheres.

According to a further feature of an embodiment of the present  
invention, the gun barrel comprises: (a) a metallic liner; and (b) composite  
material reinforcement deployed around the metallic liner.

According to a further feature of an embodiment of the present  
20 invention, at least one of the metallic liner and the composite material  
reinforcement is formed with a graduated thickness, having a maximum  
thickness at a rear end of the gun barrel and a reduced thickness towards a front  
end of the gun barrel.

According to a further feature of an embodiment of the present invention, at least part of the black powder or other low-explosive is initially stored within a metallic pressure vessel attached to, or integrally formed with, a rear end of the gun barrel.

5        According to a further feature of an embodiment of the present invention, a total mass of the gun barrel is between one and ten times a mass of the shell.

According to a further feature of an embodiment of the present invention, there is also provided a piston deployed within the gun barrel  
10    between the black powder or other low-explosive and the shell.

According to a further feature of an embodiment of the present invention, there is also provided a fuze system associated with the projectile and configured to ignite the black powder or other low-explosive when the projectile is a given distance from a target thereby firing the shell towards the  
15    target.

According to a further feature of an embodiment of the present invention, the projectile is a bomb.

There is also provided according to the teachings of an embodiment of the present invention, a projectile selected from the group comprising: a bomb  
20    and a missile, the projectile comprising: (a) a housing configured to travel stably through the air; (b) a gun barrel deployed within the housing; and (c) a shell deployed within the gun barrel, for firing from the gun barrel.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a schematic representation of the operation of a projectile  
5 constructed and operative according to an embodiment of the present invention,  
immediately after firing a shell towards a target;

FIG. 2 is a schematic cross-sectional view of the projectile of FIG. 1;  
and

FIG. 3 is an enlarged view of a gun barrel assembly from the projectile  
10 of FIG. 2.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a projectile such as a bomb which includes a shell fired from a gun barrel.

The principles and operation of projectiles according to the present  
15 invention may be better understood with reference to the drawings and the  
accompanying description.

Referring now to the drawings, FIGS. 1-3 illustrate a projectile,  
generally designated **10**, constructed and operative according to an embodiment  
of the present invention. The present invention will be illustrated herein with  
20 reference to a particularly preferred but non-limiting implementation as a  
bomb. However, it should be appreciated that the principles of the present

invention are applicable to a range of other types of projectile, such as for example a missile.

In general terms, projectile **10** has a housing **12** configured to travel stably through the air, typically formed with suitable fins **12a**. Details of the aerodynamic design and guidance system of the projectile are not relevant to the novel features of the present invention, and will therefore not be described herein. A wide range of suitable projectile designs are well known in the art.

Within housing **12** is a gun barrel **14** in which is deployed a shell **16**. Shell **16** preferably contains an explosive charge **18**. A quantity of black powder or other low-explosive **20** is preferably deployed for firing the shell from the gun barrel.

It is a particular advantage of certain embodiments of the present invention that the cannon-type gun mounted within the projectile of the present invention achieves the desired muzzle speed of shell **16** over a period of no more than about 10 milliseconds (similar to conventional artillery rounds), thereby allowing firing of the shell at significantly lower altitude (or closer range) than is possible with booster rocket-motor driven payloads. As a result of the short range of flight of the shell from the projectile to the target, the aforementioned problems of accuracy and change in attack angle are eliminated or greatly ameliorated.

A preferred orientation of the gun barrel **14** is aligned with a central axis of housing **12**, so that the shell is fired along the "boresight" axis of the

projectile. In some cases, an off-axis deployment, typically still parallel to the central axis, may be implemented.

In certain particularly preferred implementations, the dimensions of shell **16** are maximized as much as possible within the limitations of housing **12**. Thus, in some cases, an inner diameter of gun barrel **14** is at least half of the outer diameter of housing **12**.

In order to achieve the aforementioned short burn time, the present invention preferably employs "black powder", or some other low-explosive material which provides a sufficiently high burn rate. A typical primary rapid combustion propellant is M30 black powder, with G6 and/or G7 powder used as an igniter.

Firing of shell **16** according to preferred parameters of the present invention results in a pressure within the gun barrel of at least 1000 atmospheres, and typically in the order of several thousand atmospheres. In order to withstand such pressures while remaining within acceptable weight limits for the appropriate class of projectiles (e.g., air-launched bomb or missile), gun barrel **14** is preferably formed from a compound structure including a metallic liner **22** surrounded by composite material reinforcement **24**. The peak gas pressure clearly occurs at the beginning of motion of the shell, and drops off as the shell progresses along the barrel. Accordingly, as best seen in FIG. 3, at least one and preferably both of metallic liner **22** and composite material reinforcement **24** are formed with a graduated thickness, having a maximum thickness at a rear end of the gun barrel and a reduced

thickness towards a front end of the gun barrel. In the preferred implementation illustrated here, metallic liner **22** is formed with a plurality of radially projecting ridges **23** circumscribing the gun barrel and subdividing its length into regions, each of which is provided with composite material reinforcement

5 **24**. The rear end of the barrel is preferably enclosed by a metallic pressure vessel **26**, typically spherical and formed from steel, attached to, or integrally formed with, the rear end of the gun barrel, within which at least part of the black powder or other low-explosive **20** is initially stored. A piston **28** is preferably deployed within gun barrel **14**, between the black powder and shell  
10 **16**, so as to propel the shell along the barrel while protecting the shell from damage. A sabot **32** preferably supports shell **16** during motion along barrel **14** and is discarded thereafter.

The reaction against which the high-pressure gases fire the shell is provided primarily by the inertial mass of the gun barrel. Most preferably, a  
15 total mass of the gun barrel (including the pressure vessel) is between one and ten times the mass of shell **14**.

As mentioned, shell **14** is preferably fired at a given predefined stand-off distance from the intended target. To this end, projectile **10** preferably also includes a proximity fuze (not shown) or other suitable fuzing system with an  
20 associated initiating device configured to ignite the black powder or other low-explosive **20** when projectile **10** reaches the given distance from the target. Ignition of the explosive charge **18** of shell **16** is typically performed by a separate fuze **30** within shell **16**.

It will be appreciated that the above descriptions are intended only to serve as examples, and that many other embodiments are possible within the scope of the present invention as defined in the appended claims.

WHAT IS CLAIMED IS:

1. A projectile selected from the group comprising: a bomb and a missile, the projectile comprising:

- (a) a housing configured to travel stably through the air;
- (b) a gun barrel deployed within said housing, said gun barrel comprising:
  - (i) a metallic liner having a plurality of radially projecting ridges circumscribing said gun barrel and subdividing a length of said gun barrel into regions, and
  - (ii) composite material reinforcement deployed around said metallic liner within each of said regions;
- (c) a shell deployed within said gun barrel, said shell containing an explosive charge; and
- (d) a quantity of black powder or other low-explosive deployed for firing said shell at a muzzle velocity from said gun barrel.

2. The projectile of claim 1, wherein said housing has a central axis, and wherein said gun barrel is aligned with, or parallel to, said central axis.

3. The projectile of claim 1, wherein said housing has an outer diameter, and wherein said gun barrel has an inner diameter at least half of said housing outer diameter.

4. The projectile of claim 1, wherein said black powder or other low-explosive is configured to have a burn-time of not more than 10 milliseconds.

5. The projectile of claim 1, wherein said black powder or other low-explosive is configured to generate a pressure within said gun barrel of several thousands of atmospheres.

6. The projectile of claim 1, wherein at least one of said metallic liner and said composite material reinforcement is formed with a graduated thickness, having a maximum thickness at a rear end of said gun barrel and a reduced thickness towards a front end of said gun barrel.

7. The projectile of claim 1, wherein at least part of said black powder or other low-explosive is initially stored within a metallic pressure vessel attached to, or integrally formed with, a rear end of said gun barrel.

8. The projectile of claim 7, wherein said metallic pressure vessel is a generally spherical pressure vessel.

9. The projectile of claim 1, wherein a total mass of said gun barrel is between one and ten times a mass of said shell.

10. The projectile of claim 1, further comprising a piston deployed within said gun barrel between said black powder or other low-explosive and said shell.

11. The projectile of claim 1, further comprising a fuzing system associated with the projectile and configured to ignite said black powder or other low-explosive when the projectile is a given distance from a target thereby firing said shell towards the target.

12. The projectile of claim 1, wherein the projectile is a bomb.

13. A projectile selected from the group comprising: a bomb and a missile, the projectile comprising:

- (a) a housing configured to travel stably through the air;
- (b) a gun barrel deployed within said housing, said gun barrel comprising:
  - (i) a metallic liner having a plurality of radially projecting ridges circumscribing said gun barrel and subdividing a length of said gun barrel into regions, and
  - (ii) composite material reinforcement deployed around said metallic liner within each of said regions; and
- (c) a shell deployed within said gun barrel, for firing from said gun barrel.

14. The projectile of claim 13, further comprising a generally spherical metallic pressure vessel attached to, or integrally formed with, a rear end of said gun barrel.