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EXPLOSIVE CHARGE CONSTRUCTION

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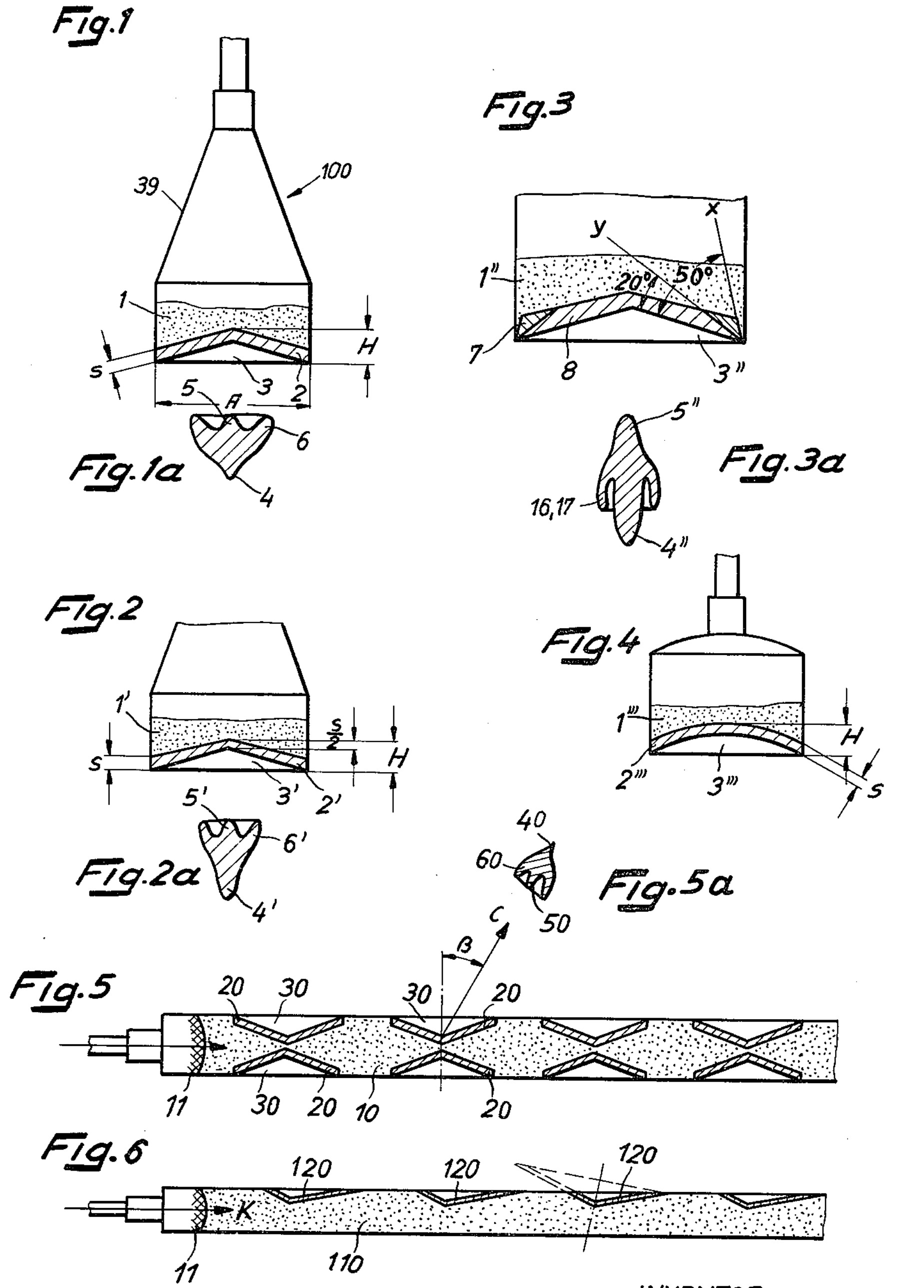

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EXPLOSIVE CHARGE CONSTRUCTION

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This invention generally relates to explosive charge constructions and is particularly directed to a novel and improved projectile-forming explosive charge having a cavity which is open in the firing direction and which is lined by a liner of suitable material such as, for example, metal.

As is known, when an explosive charge, which is coated with a metal layer, is detonated, the metal layer is torn into many individual fragments or splinters which are hurled off in various directions, the splinter speed being inversely proportional to the splinter size.

It is also known that the detonation of a hollow explosive charge of the kind wherein the hollow space or cavity is lined with a metal liner causes the formation of a projectile-like structural body (hereinafter referred to as "projectile") which is formed by deformation of the metal liner. This projectile comprises a leading thorn or spike, a trailing tail or bolt-like member and a certain amount of residual material which pertains neither to the thorn nor to the bolt. Dependent on the shape of the liner of the hollow charge, the leading thorn is imparted with speeds of several kilometers per second. By contrast, the bolt-like trailing body reaches only speeds of several hundred meters per second. Finally, the residual material of the projectile formed from the liner moves with a speed which is comparable to the speed of the splinters or fragments formed from simple metal layers provided at the walls of explosives. The speed of the thorn and of the bolt is reduced and approaches that of the splinter speed referred to, if the shape of the cavity or hollow space is made flatter. Either the thorn or the bolt tends to be torn off from the residual mass if the speeds of the thorn, the residual mass and the bolt, respectively, differ from each other to an appreciable extent.

It is a primary object of this invention to provide a projectile-forming explosive charge which has superior armor piercing ability.

Another object of this invention is to provide a projectile-forming explosive charge, wherein the projectile formed upon detonation has superior flying characteristics and moves at great speed.

Another object of the invention is to provide for a projectile-forming explosive charge which is safe, simple in construction and inexpensive to manufacture.

Generally, it is an object of this invention to improve on the art of explosive charges having cavities lined with metal liners as hitherto practiced.

It is also an object of this invention to provide a projectile-forming explosive charge wherein the thorn and the bolt remain united with the residual mass or material of the liner to increase the penetrating ability of the projectile, the latter assuming a uniform speed.

A further object of the invention is to provide a projectile-forming explosive charge wherein the cross section of the projectile is relatively small and has favorable and stable flying characteristics.

Briefly, and in accordance with an essential feature of the inventive explosive charge construction, the cavity or hollow space forms an apex, the apex height amounting to about between 10 to 30% of the diameter of the cavity while the wall thickness of the liner amounts to about between 5 to 10% of that diameter. It has been ascertained that the superior characteristics referred to are obtained in an explosive charge construction wherein the cavity and the liner are within the dimensional limitations referred to.

According to a further feature of the invention and with a view to increasing the speed of the projectile, the wall thickness of the liner may be decreasing in the direction from the rim or periphery toward the axis or apex. In order to obtain a particularly slim and oblong projectile of small cross section, the thinnest wall thickness of the liner at the location of the axis or apex of the liner may decrease to a value which is about one-half the wall thickness of the liner at the outer diameter or periphery of the cavity.

The speed of the projectile may be still further increased by including in the liner construction a cone-shaped separating ring of lower specific weight than that of the remaining portion of the liner. This separating ring thus divides the liner construction into an outer ring and an inner disc or plate. Such an embodiment is suitable for many purposes. The provision of the separating ring makes the projectile to be formed upon detonation more compact. Those marginal or rim portions of the liner which are made up by the ring are caused to flap or bend over frontwardly in the flying direction upon detonation of the explosive charge. This phenomenon is due to the smaller mass of the ring which, in turn, results in a greater speed thereof.

With a view to preventing that the separating ring, due to its greater speed, is torn off upon detonation from the inner disc which forms the bolt and the thorn, the invention provides, according to a further feature, that the angle between the generatrix of the separating cone or ring and the generatrix of the disc forming liner portion is between about 20 and 50°.

According to a further feature of the inventive explosive charge construction, the explosive charge may be provided with a single liner so that only a single projectile is formed upon detonation, or a plurality of liners or coating layers may be provided at the explosive charge. In accordance with the invention, the axes of rotation of the individual liners in the second instance may extend in different directions. In this manner, an explosive charge may be obtained which, upon detonation, forms a plurality of projectiles of exactly defined flying directions, suitable projectile weights and predetermined hurling speeds.

In explosive charges of the above indicated kind, it is generally presumed that the detonation takes place in the axial direction of the cavity. Due to such axial detonation, projectile bodies are formed which are symmetrical with respect to rotation, that is, they are axially symmetrical. The invention, however, is not restricted to explosive charges of this kind but also embraces exposive charges wherein the detonation takes place at an angle relative to the axial direction of the cavity. In the latter event, projectiles of distorted form are formed because the detonation pressure wave which extends obliquely or transverse laterally squeezes the liner prior to hurling to form a projectile of substantially elliptical cross section. Such deformation is undesired in many instances and may be prevented in accordance with the invention. Thus, according to a further feature of the invention, the liner may be cut off in a direction obliquely relative to the axis of rotation of the liner and the liners may be arranged at the explosive charge in a slanted direction relative to the direction of the detonation wave.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

In the drawings:

FIG. 1 is a somewhat diagrammatical longitudinal section through an inventive explosive charge having a cone-shaped cavity liner, the wall thickness of the liner being constant throughout;

FIG. 1*a* illustrates in longitudinal section the characteristic shape of a projectile which has been formed from the liner of FIG. 1 upon detonation of the explosive charge;

FIG. 2 shows a different embodiment of an explosive charge in a view similar to that of FIG. 1 wherein, however, the wall thickness of the liner steadily decreases in a direction from the periphery toward the axis or apex;

FIG. 2*a* illustrates a projectile formed upon detonation of the explosive charge of FIG. 2;

FIG. 3 illustrates a still further embodiment of an inventive explosive charge having a liner with steadily decreasing wall thickness in a direction from the rim to the axis, the liner including a cone-shaped separating ring which divides the liner into an inner disc and an outer ring;

FIG. 3*a* illustrates a projectile formed by the explosive charge of FIG. 3;

FIG. 4 shows a still further embodiment of an explosive charge wherein the cavity is lined by a dome-shaped liner of constant wall thickness;

FIG. 5 shows an extended explosive charge embodiment in longitudinal section having several liners of constant wall thickness which are arranged on opposing sides of the charge;

FIG. 5*a* shows the characteristic shape and flying direction of a projectile formed from one of the liners of FIG. 5; and

FIG. 6, in a view similar to FIG. 5, represents a still further embodiment of an extended explosive charge having a plurality of liners which are cut off obliquely relative to their rotational axes and which are arranged inclinedly relative to the direction of the detonation pressure wave.

For the sake of simplicity, similar elements of the various embodiments illustrated in the drawings have been indicated by the same reference numerals.

Referring now to the drawings, and particularly FIGS. 1 and 1*a*, reference numeral **100** generally indicates an explosive charge construction comprising a casing **39** accommodating explosive material **1**. The casing includes a front cavity or hollow space **3** which is open in the firing direction. The cavity **3** is lined with a liner **2**. The liner **2** is of metal which is easily formed or malleable and, as a particularly suitable example, carbon-free iron is proposed for this purpose. It will be noted that the shape of the liner of the embodiments of FIGS. 1 through 3 is conical.

According to an essential feature of the invention, the apex height H of the hollow space **3** amounts to 10 to 30% of the diameter A of the cavity. Further, the wall thickness *s* of the liner amounts to from 4 to 10% of the diameter A. These dimensional relations are critical for obtaining the desired effects.

The wall thickness of the liner **2** in FIG. 1 is constant from the outer rim or periphery to the apex or axis. Upon detonation of the explosive charge **100** of FIG. 1, the liner **2** is deformed into a projectile-like body which is axially symmetrical with regard to rotation. This body is shown in FIG. 1*a* and consists of the leading thorn or spike **4**, the trailing bolt **5** and the residual connecting material **6**.

The embodiment of FIG. 2 is similar to that of FIG. 1 with the sole difference that the wall thickness of the liner **2'** decreases from the rim or peripheral portion toward the apex or axis. Thus, it will be noted that the wall thickness *s* at the periphery of the cavity **3'** is about twice

the amount of the wall thickness at the apex, as indicated by *s*/2. Again, however, the dimensional relation with regard to the apex height H and the wall thickness in relation to the diameter of the cavity is adhered to. It will be noted that the decrease of the wall thickness of the liner is gradual and steady. Due to this progressive weakening of the wall of the liner, a projectile is formed upon detonation which, as compared to the projectile of FIG. 1*a*, has a slimmer and longer shape with more stable flying characteristics. This projectile is indicated in FIG. 2*a*, wherein the thorn, the bolt and the residual material bear reference numerals **4'**, **5'** and **6'**, respectively.

As previously mentioned, the projectile speed can be increased, in accordance with this invention, by providing a cone-shaped separating ring of lower specific weight than that of the remaining portion of the liner. Such an embodiment is shown in FIG. 3, wherein the conical separating ring **7** forms the outer portion of the liner while the inner portion **8** thus assumes the shape of a generally conical disc or plate. The cone-shaped separating ring **7** may be made of, for example, aluminum, while the inner disc-shaped plate member **8** may again be made from carbon-free iron. In order to obtain a slim projectile, the wall thickness of the liner again decreases in a constant manner toward the apex of the cavity **3''**.

Since the separating ring **7**, upon detonation of the explosive charge **1''**, due to its larger mass speed has a tendency to tear off from the disc portion **8**, suitable measures have to be adopted to prevent this phenomenon. Accordingly, the invention provides, in accordance with a further feature thereof, that the angle between the generatrix *x* for the separating cone-like ring and the generatrix *y* of the interior disc portion has a value between about 20 to 50°. This is clearly indicated in FIG. 3.

FIG. 3*a* indicates a projectile which is formed upon detonation of the explosive charge of FIG. 3. The leading thorn or spike is indicated by reference numeral **4''** and extends in the flying direction while the formation of the trailing bolt **5''** is visible at the rear of the projectile. It will also be noted that contrary to the embodiments of FIGS. 1*a* and 2*a*, two forward pointing members **16** and **17** are formed which correspond to the separating ring and part of the residual mass. This bending over of these lateral portions **16** and **17** is due to the lower specific weight of the separating ring **7**.

Referring to FIG. 4, it will be noted that the liner **2'''** in this embodiment is of dome shape. The wall thickness of the dome is constant throughout and for this reason such liner forms upon detonation a projectile-like body similar to the one shown in FIG. 1*a*.

In the embodiments of FIGS. 1 through 4 the detonation of the charge takes place in axial direction. This, in turn, means that the liner is hurled off in axial direction and the formation of the projectile also takes place with great accuracy in axial direction. By contrast, if the detonation takes place in a direction transverse to the axis of rotation of the liner, the liner is hurled off under a predetermined angle, i.e. the projectile which is formed moves with one component in the direction of the detonation so that the flying direction of the projectile includes an angle with the original axis of rotation of the liner. This angle is indicated in the embodiment of FIG. 5 by the reference letter β. The embodiment of FIG. 5 generally illustrates an extended explosive charge **10** which has attached thereto several liners **20** at opposite sides. These liners line corresponding cavities **30**. Due to this arrangement, the individual liners are hurled off in different directions. The course of the detonation wave which in FIG. 5 has been indicated by reference numeral **11**, extends laterally in direction of the arrow *k*. This detonation pressure wave hurls the individual liners **20** in a direction indicated by the arrow C, that is, in a direction which is inclined relative to the axial direction of the explosive charge. During the hurling of the liners, the latter are squeezed together to form an assymmetrical projectile whose cross section is somewhat elliptical. FIG. 5*a* illustrates such projectile formed from the liner of FIG. 5. The thorn, the bolt and the residual mass are indicated by reference numerals **40**, **50** and **60**, respectively.

The assymmetrical deformation of the projectile of FIG. 5*a* may negatively affect the flying stability of the projectile. Therefore, the invention, according to a further embodiment as illustrated in FIG. 6, provides that the liners **120** are cut off obliquely relative to their axes of rotation. In addition, the liners are arranged at the explosive charge **110** in a slanted or inclined direction relative to the direction of the detonation wave **11**.

The invention, independent from the particular shape of the explosive charge with its cavity and liner, provides for a construction wherein the formed projectile, as compared to prior art constructions, has more stable flying characteristics and reaches considerably increased speeds. Further, in the inventive construction, the projectile has a larger mass and therefore a better penetration and piercing capacity. The invention embraces explosive charges which form projectiles of several kilogram weight. Further, it is certainly within the scope of this invention to provide explosive charges forming projectiles which move with a speed of between 1400 and 2000 meters per second.

While specific embodiments of the invention have been shown and illustrated in detail to illustrate the application of the inventive principles, it will be understood that this invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. In an explosive charge construction including a casing having a cavity which is open in the firing direction and is lined with a liner, wherein the liner upon detonation of the explosive charge forms a projectile-like body, the improvement which comprises that the cavity converges inwardly to a peak, the height of the peak being in excess of 10% but not exceeding 30% of the diameter of the cavity and the layer thickness of said liner being in excess of 4% but not exceeding 10% of said diameter.

2. The improvement as claimed in claim **1**, wherein the layer thickness of said liner is greater at the periphery of said cavity than in the region of said peak.

3. The improvement as claimed in claim **1**, wherein the layer thickness of said liner steadily decreases from the periphery of the cavity toward said peak.

4. The improvement as claimed in claim **1**, wherein the layer thickness of said liner decreases from the periphery of said cavity toward said peak, the layer thickness at said peak being about one-half of the layer thickness at said periphery.

5. The improvement as claimed in claim **1**, wherein said liner comprises an outer annulus and an interior disc-like portion adjacent said annulus, said annulus having a lower specific weight than said disc-like portion, said outer annulous and said disc-like portion, upon detonation of the explosive charge, receiving an impulse and conjointly forming the projectile-like body.

6. The improvement as claimed in claim **5**, wherein said annulus is cone-shaped.

7. In an explosive charge construction including a casing having a cavity which is open in the firing direction and is lined with a liner, wherein the liner upon detonation of the explosive charge forms a projectile-like body, the improvement which comprises that the cavity converges inwardly to a peak, the height of the peak being about between 10 to 30% of the diameter of the cavity and the layer thickness of said liner being about between 5 to 10% of said diameter; said liner comprising an outer, cone-shaped annulus and an interior disc-like portion adjacent said annulus, said anulus having a lower specific weight than said disc-like portion; and wherein the angle between the generatrix for said cone-shaped annulus and the generatrix for said disc-like portion is between about 20 to 50°.

8. In an explosive charge construction, as claimed in claim **1**, the casing having a plurality of external cavities, each of said cavities being lined with a metal liner, said liners upon detonation of the charge forming projectile-like bodies, the axes of rotation of the individual liners extending in different directions.

9. In an explosive charge construction including a casing having an external cavity wherein the cavity is lined with a liner having an axis of rotation which includes an angle with the direction of detonation of the explosive charge, wherein the liner upon detonation of the charge forms a projectile-like body, the improvement which comprises that the cavity has a peak, the height of the peak being about between 10 to 30% of the diameter of the cavity and the layer thickness of said liner being about 5 to 10% of said diameter, said liner being cut off in a direction which is inclined to the axis of rotation of the liner, said liner being arranged at said explosive charge in a direction which is slanted relative to the direction of the detonation wave formed upon detonation of the charge.

10. The improvement as claimed in claim **1**, wherein said liner is generally dome-shaped.

11. The improvement as claimed in claim **1**, wherein said liner is generally dome-shaped.

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