(12) UK Patent Application (19) GB (11) 2472571 (13) A

(43) Date of A Publication 16.02.2011

(21) Application No: 0913825.6

(22) Date of Filing: 07.08.2009

(71) Applicant(s):
The Exploding Target Company Ltd
35 Jacobean Road, Doddington Park, LINCOLN, Lincolnshire, LN6 3RB, United Kingdom

(72) Inventor(s):
Paul Thomas Albert Mulvihill

(74) Agent and/or Address for Service:
Loven
West Central, Runcorn Road, LINCOLN, LN6 3QP, United Kingdom

(51) INT CL:
C06B 45/16 (2006.01) ***F41B 9/00*** (2006.01)
F41J 5/24 (2006.01) ***F41J 9/16*** (2006.01)

(56) Documents Cited:
GB 2454863 A **GB 1263522 A**
WO 2002/035175 A

(58) Field of Search:
INT CL **C06B, F41J, F42B**
Other: **ONLINE: WPI, EPODOC**

(54) Title of the Invention: **Pyrotechnic target**
Abstract Title: **Pyrotechnic target**

(57) A target is disclosed which contains a series of pyrotechnic components so arranged as to produce a highly visual and/or audible pyrotechnic effect when struck. The target comprises a hollow body having a front face 1 spaced from a base 8, the body containing, in sequence between the base and the front face, a layer 11 of red phosphorus on the base, a separator 3 spaced from the base to provide an air gap 7 between the separator 3 and the phosphorus layer 11, and a compartment 4 between the separator 3 and the front face 1. The compartment 4 contains a quantity of pyrotechnic chemical material 9 having deflagrating pyrotechnic characteristics, the body and the separator 3 being of materials such that a projectile striking the front face 1 will pass through the front face 1 and through the separator 3 bringing the pyrotechnic material 9 into contact with the red phosphorus layer 11 with sufficient agitation to cause ignition of the pyrotechnic material 9.

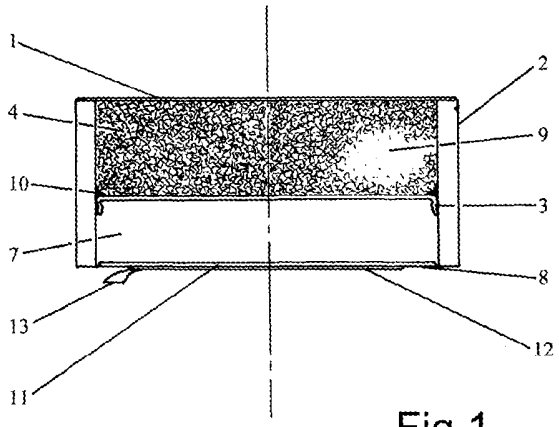

Fig 1

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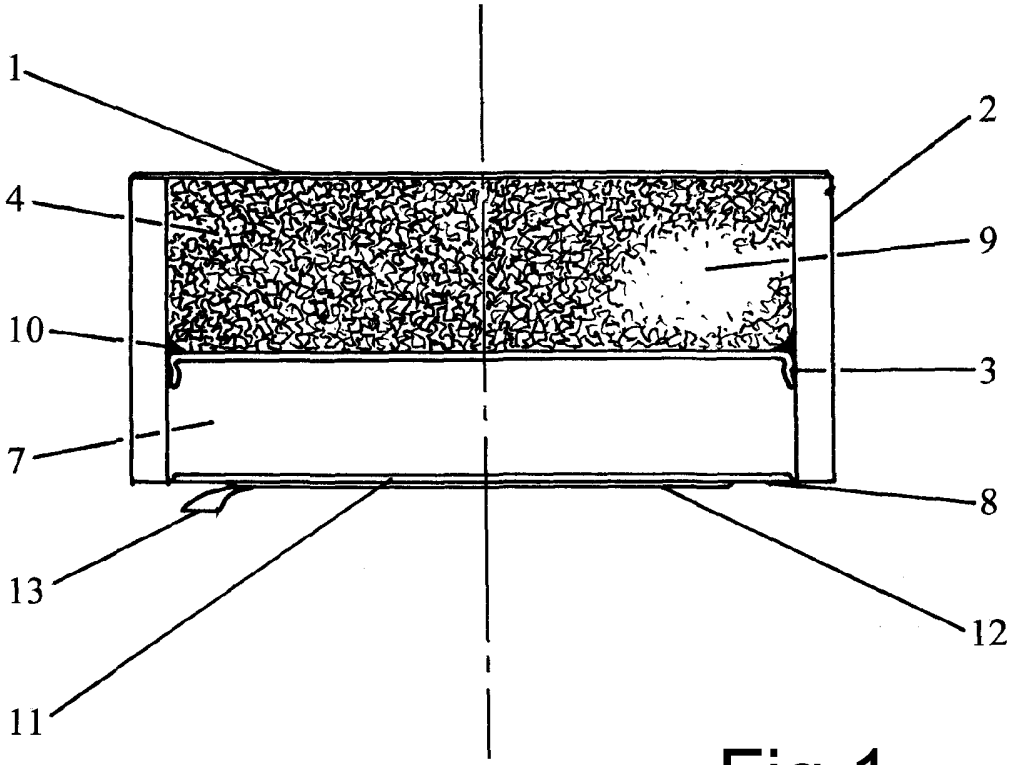


Fig 1

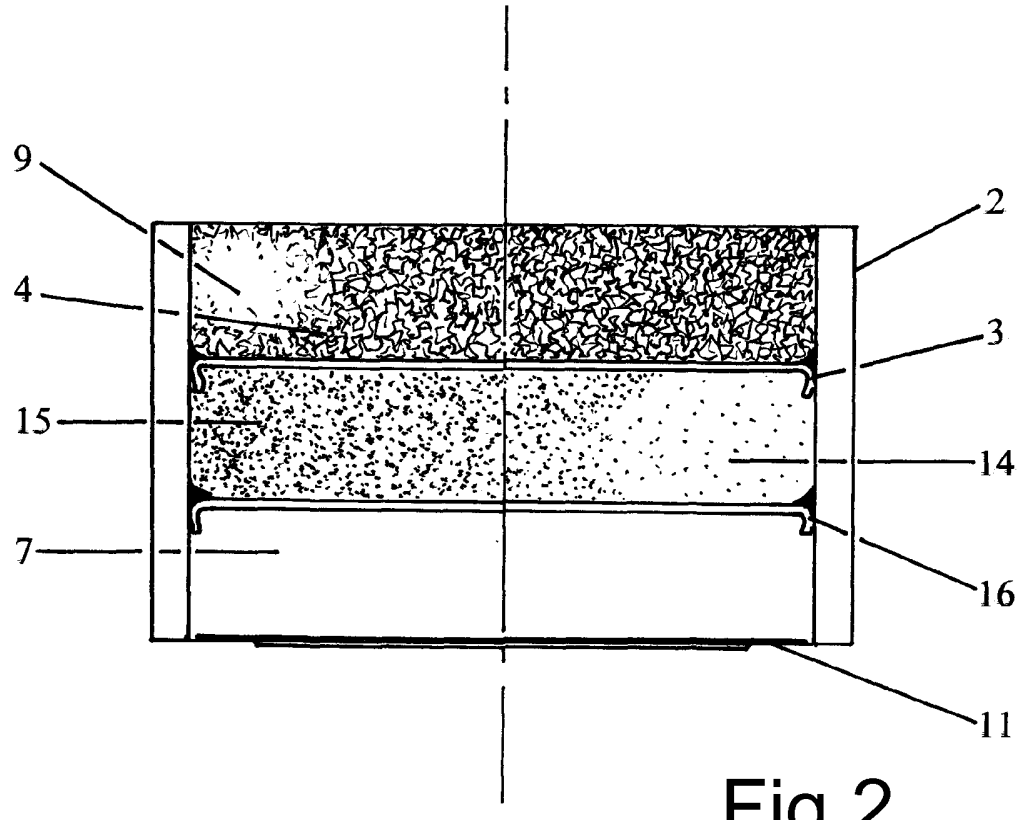


Fig 2

Fig 3

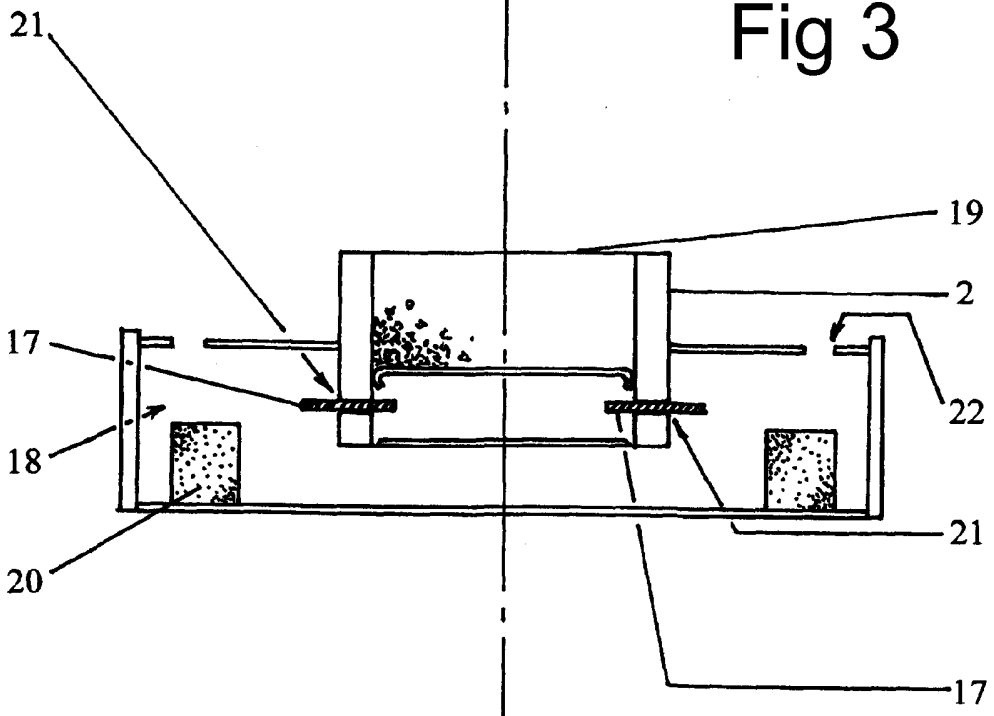
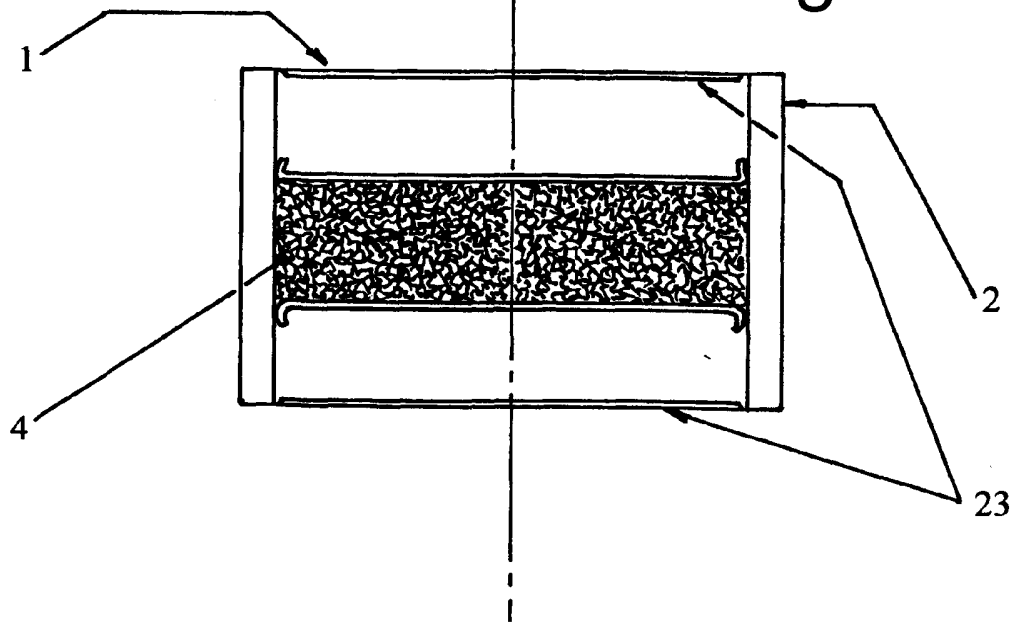


Fig 4



PYROTECHNIC TARGET

Field of the Invention

This invention relates to a pyrotechnic target for pistol, shotgun and air weapon target practice.

Background to the Invention

Targets have been employed for training and recreational purposes for many years. Such targets may be static and positioned for use at extended ranges for sniper training, static and positioned for use at short range for recreational shooting involving pistols and air weapons, or can take the form of a clay pigeon which is a moving target.

In each of the three examples given, a successful "hit" can be difficult to immediately recognise and/or un-entertaining to a spectator or the person delivering the shot.

Pyrotechnic or exploding targets are known. Their designs and formulations however suffer from a number of disadvantages, in that they are considered too dangerous and chemically unstable for commercial production and supply. This is particularly so in the United Kingdom, where explosives-related legislation specifically restricts the use of certain chemicals in combination.

WO0235175 describes a number of targets having various methods of construction and a number of formulations. One option described refers to a formulation containing a mixture of a particulate chlorate or perchlorate in combination with aluminium flash powder, coarse titanium granules and flake aluminium flitters. Mixtures, however, containing both metal powders and chlorates in combination with one another are widely considered as being excessively sensitive to shock and friction and, may be subject to operational and legal restrictions and prohibitions where production and supply is concerned in the United Kingdom.

The alternative and substituted use of a perchlorate as described can overcome this problem. However, its use is accompanied by a consequential and considerable decrease in sensitivity, and such a formulation would therefore be unsuitable for use in any target employed for low energy projectiles such as air weapons, where it would fail to function reliably, if at all.

A second option described in **WO0235175** refers to a formulation containing resorcinol resin, hardener, potassium chlorate, fine aluminium and coarse magnesium.

Ignition is said to occur when the mixture in the target is struck by a phosphorus-carrying shotgun pellet, presumably as a consequence of the reducing properties of the phosphorus, the kinetic energy occurring on impact and, the relatively sensitive nature of the formulation specified.

Such an arrangement suffers from a number of disadvantages. Firstly, the use of a mixture containing both a chlorate and metal powders, in particular aluminium and magnesium, in the United Kingdom would, as has been outlined in the previous example, be the subject of controls, restrictions and possible prohibitions due to its highly sensitive nature. Mixtures of magnesium and chlorates are declared “prohibited mixtures” under current U.K. explosives legislation.

Secondly, in order to ensure consistently reliable ignition levels in such an arrangement, relatively large quantities of red phosphorus need to be supplied to the chlorate-containing composition in order that the required area of surface interaction between the two chemical mixtures is achieved and then, energetically so. In view of the somewhat restricted size of the pellet carrying the phosphorus, it is unlikely that a sufficient quantity of phosphorus could be applied to the surface of the projectile and therefore delivered to the chlorate-containing composition to bring about reliable ignition.

Thirdly, the exposure of red phosphorus to both the heat energy delivered by the propellant charge within a shotgun cartridge and the dynamic and abrasive forces experienced on propulsion would oxidise and therefore further reduce the limited quantity of material present necessary to reliably ignite the target composition.

A third option described in **WO0235175** refers to a similarly formulated composition and also describes a system of preparation wherein the operator assembles a second component to the target containing a surface coating partly composed of red phosphorus. The design suffers from the disadvantage al-

ready outlined in the previous two examples in that the same problematic formulation is proposed containing both a chlorate and metal powders.

A second disadvantage is that the preparation of such a target, in addition to being potentially hazardous, would constitute an act of manufacture and, would therefore be prohibited in the United Kingdom under current legislation in any circumstances other than those wherein

(a) the individual undertaking the task were to hold a license to manufacture explosives and specifically that directly authorising the act of preparing the target and:

(b) the act of manufacture were to take place in a factory licensed specifically for that purpose and in a place within the factory specifically appropriated for the application of target assembly.

US4498677 also describes a target, specifically one containing a composition formulated to include a mixture of aluminium, potassium chlorate and sulphur. This mixture suffers from the profound disadvantage in that the formulation quoted contains a blend of chemicals, namely that of sulphur and potassium chlorate, quite specifically defined within the Explosives Act of 1875 and the Manufacture and Storage of Explosives Regulations of 2007 as a prohibited mixture for the purposes of manufacture, importation, sale and distribution within the United Kingdom.

The examples referred to illustrate clearly the difficulties posed by the challenges of formulating a single composition or, an arrangement of pyrotechnic elements capable of reacting in combination with one another explosively or in a deflagrating manner, to the physical impact of a projectile, striking a target containing such components and compositions.

The clear and common pattern of development highlighted by the two examples referred to demonstrates an historical tendency to:

(i) Increase the sensitivity of the pyrotechnic composition by the use of a chlorate, most commonly potassium chlorate, in order to ensure that the composition will react to the stimulus of shock and friction associated with a projectile strike;

(ii) Produce a highly visible effect by the use of an energetic fuel such as a metallic powder, most commonly magnesium or aluminium.

(iii) Combine both the chlorate compound to achieve the required level of sensitivity and the metal powder(s) to achieve visual effect.

The combined use of a friction-sensitive oxidising agent (such as potassium chlorate) alongside the visually intensive metal powders (such as magnesium or aluminium) effectively negates the target designs mentioned insofar as manufacture, sale and supply within the United Kingdom yet, without the combination as described, the mixture is not sufficiently sensitive to ignite as a direct result of the impact of a low energy projectile.

The use of a reducing agent such as red phosphorus to reduce an oxidising agent such as potassium chlorate effectively enough to cause ignition and/or deflagration can only be achieved successfully if, in the absence of substantial levels of kinetic energy, sufficient levels of phosphorus are introduced to the reaction and, where a reduced or relatively small quantity of phosphorus is being employed, the level of purity necessary to initiate a reaction needs to be substantially increased.

The high levels of energy required to propel a projectile carrying small quantities of red phosphorus, for example a coating, and successfully bring about ignition on impact with a pyrotechnic composition would be likely to cause ignition as a direct result of the impact energy alone. The phosphorus would therefore be ineffective and unnecessary.

It is unlikely that the levels referred to in the third example of **WO0235175** will be capable of being delivered as a payload on a small projectile such as a bullet because:

(a) Such a projectile would be too small to carry a sufficient quantity of phosphorus;

(b) The exposure of such a projectile to the dynamic forces of acceleration, spin and abrasion experienced in a gun barrel as well as the momentary high temperatures accompanying propulsion would degrade the levels of phosphorus to levels below that needed; and

(c) The introduction of a chemical binder or additive to counter the effects referred to in (b) would further reduce the reactivity of the phosphorus below the level needed to ensure a reaction.

A commonly recognised and appreciated example of the type of pyrotechnic reaction referred to above is that of the safety match, and a practical example of the problem referred to is that of poor quality matches failing to ignite "first strike" for the reasons described above, poorly formulated (or in the case of old match boxes over-worked and worn out) striker composition providing insufficient quantities of low purity phosphorus and/or insufficient energy applied between the match head (which contains a source of potassium chlorate) and the striker panel during the striking process.

In cases such as those described above, the match would fail to ignite first strike and a second strike would be necessary to procure ignition. In the case of a target similarly affected, a second strike would be wholly practical and a "hit" would not be registered as such.

In considering the need for abrasive agitation to ensure reliability, a third drawback has been identified as being directly attributable to the relatively fluid nature of the powdered pyrotechnic composition. Consequently, the level of resistance at particulate level in free flowing, finely divided powders is less than that observed within coarse, granular powders where the solid particles are irregular in shape. The abrasive interaction between comparatively larger, rougher particles affords greater interactive resistance to incoming phosphorus-coated particles penetrating the mix and, as a result of this, substantially increased probability of ignition.

A fourth drawback associated with the use of finely divided powders is settlement, which occurs particularly when the target is positioned vertically, causing the creation of a void at the uppermost level within the target itself. The use of granulated composition as described ensures and maintains a more efficient means of filling the space envelope within the target housing, reducing the potential for voids which might otherwise occur as a result of powder settlement and which could create "dead" spots within the target.

Summary of the Invention

In considering the background to the invention and with reference to the technical problems outlined concerning the physical and chemical characteristics of powders previously the invention incorporates the following improvements;

Against this background and according to the present invention there is provided a pyrotechnic target comprising a hollow body having first and second ends and containing at a first end thereof an internal surface bearing a layer of red phosphorus, a separator spaced from the first end to provide an air gap between the separator and the phosphorus layer, and a compartment between the separator and the second end, the compartment containing a quantity of pyrotechnic chemical material having deflagrating pyrotechnic characteristics, the body and the separator being formed of materials such that a projectile striking the second end will pass through the compartment and through the separator bringing the pyrotechnic material into contact with the red phosphorus layer with sufficient agitation to cause ignition of the pyrotechnic material.

The body, the air gap and the separator may also be such that a projectile striking the first end will carry red phosphorus through the air gap and the separator into the pyrotechnic material with sufficient agitation to cause ignition of the pyrotechnic material. In this way, the target may be used reversed, which could be important if the target is incorporated into a clay pigeon target and is struck by a projectile from the opposite face.

Preferably, the pyrotechnic material is in granular form, and more preferably the granular form of the composition should be coarse, brittle, irregularly shaped with sharp edges and substantial enough in size to allow the formation of open voids between the poorly tessellated particle structure, to assist with the passage of phosphorus-coated particles penetrating and travelling through the composition, and to allow free movement between particles in the presence of the phosphorus, present as a foreign body and forcibly introduced by the projectile, typically a bullet.

A second advantage associated with the creation of a granular structure as described above also promotes a faster burn rate, necessary to ensure a

sharp reaction to the "hit" by enabling rapid transfer of heat energy throughout the charge as a whole and consequently, a more effective ignition transfer from granule to granule.

A third advantage associated with the creation of a granular structure as described above is the ability of the charge as a whole to maintain its integrity in situations of extreme dynamic force such as those encountered when the target is attached to a clay pigeon or some other form of moving target.

In view of the above, the powder should comprise a physically bound, granular blend of chemical ingredients, with each individual chemical component within the blend having a particle size substantially below that of grain size and typically not greater than 100 microns. The physical binding of the chemical components prevents migration and separation thus ensuring an efficient burn. The use of coarse individual chemical components to achieve the same effect *physically* encourages separation resulting in "un-mixed" composition and ignition failures or very erratic performance.

Accordingly, another aspect of the invention provides a pyrotechnic target containing a pyrotechnic material in granular form with voids between the grains.

In view of the requirement for the target composition to react to the introduction of red phosphorus, a chlorate must be present, preferably potassium chlorate. A preferred composition is shown as follows:

potassium chlorate……70 parts

potassium benzoate……30 parts

resorcinol resin……16 parts

The mixture is granulated by passing through a coarse sieve, the preferred grain size is above 1.0mm in any one plane, either diametrically or in width or length and, less than that half the diameter of the incoming projectile.

A further aspect of the invention provides a pyrotechnic target containing an oxidant and a benzoate or salicylate as fuel. Preferably, the oxidant is a chlorate, more preferably potassium chlorate, and the fuel is potassium benzoate or potassium salicylate.

A preferred formulation for the red phosphorus composition is shown as follows:

red phosphorus.....85 parts

shellac.....15 parts

The composition is first damped with a suitable solvent such as methylated spirits or methanol and then applied as a wet coating onto the desired component.

Yet another aspect of the invention provides a pyrotechnic target comprising a body containing a first pyrotechnic charge ignitable by a projectile bringing the material into agitated contact with red phosphorus, and a second pyrotechnic charge adapted to produce a different visual and/or audible effect from the first charge, the second charge being ignited by ignition of the first charge, the first and second charges being separated one from the other in the body by means of a frangible separator.

Brief Description of the Drawings

An example of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a cross sectional view of a target containing a single, a low energy effect;

Figure 2 is a cross sectional view of a target containing a plurality of high energy effects;

Figure 3 is a cross-sectional view of a target according to another embodiment of the invention, having an alternative means of coupling a secondary pyrotechnic charge to the reactive element of the target; and

Figure 4 is a cross-sectional view of yet another embodiment, in which two air gaps are provided on opposite sides of the pyrotechnic charge.

Detailed Description of the Illustrated Embodiment

Referring to Figure 1, a granulated pyrotechnic composition (4) formulated to include a chlorate, preferably potassium chlorate, is housed within a body (2) and retained within that body (2) in a composition chamber (9) formed between the inner walls of the body (2), the front-face closure (1) and an internal separator (3). The front-face closure (1) may feature a printed target decal

for aiming and decorative purposes and will be constructed from a low density material such as paper.

Immediately adjoining the composition chamber (9) on the opposite side of the internal separator (3) to the front-face closure (1) is an empty chamber (7). The composition chamber (9) and the empty chamber (7) are therefore separated from one another by the internal separator (3) which is preferably constructed from low density material such as lightweight board or paper and are at opposite ends of the body (2). An adhesive seal (10) is maintained around the edges of the internal separator (3) by means of a sealing medium such as P.V.A. glue, this adhesive seal (10) preventing the migration and leakage of the granulated pyrotechnic composition (4) from the composition chamber (9) and into the empty chamber (7).

The empty chamber (7) is formed between the internal walls of the body (2), the internal separator (3), and a rear closure plate (8) securely attached externally to the ends of the body (2) by means of an adhesive seal (10). The rear closure plate (8) comprises a self adhesive panel (12) on one side and a red phosphorus based surface coating (11) on the other side. The rear closure plate (8) is attached to the body (2) with the red phosphorus based surface coating (11) facing inwards, towards the internal separator (3) and with the self adhesive panel (12) facing outwards. The adhesive material on the self adhesive panel (12) is protected by and covered with a removable cover (13) which should remain in position until ready for use.

The granulated pyrotechnic composition (4) is formulated such that it is capable of being readily reduced and thus caused to ignite by the red phosphorus contained within the red phosphorus based surface coating (11) when sufficiently agitated by a source of energy. On ignition, the granulated pyrotechnic composition (4) deflagrates energetically to produce a display of light, smoke and audible noise.

To operate, the target is attached to a suitable solid surface, the removable cover (13) being removed to reveal the self-adhesive panel (12) and the target attached to the surface with the front-face closure (1) facing towards the direction of fire. This is achieved by simply pressing the target against the solid

surface and ensuring that pressure and contact are maintained between the self adhesive panel (12) and the solid surface thus ensuring a bond.

A projectile such as a bullet or air-gun pellet registering a successful "hit" on a target prepared in the manner described in the preceding paragraph will penetrate the front-face closure (1) at great speed and, having done so, will proceed to further penetrate the composition chamber (9) containing the granulated pyrotechnic composition (4). The physical barriers intervening the progress of the projectile, the front-face closure (1), the granulated pyrotechnic composition (4) and the internal separator (3) offer negligible resistance to the projectile, which proceeds through the empty chamber (7) before striking the rear closure plate (8) at considerable speed.

The coarse grained nature of the granulated pyrotechnic composition (4) is such that there is a natural tendency for the granular particles to be pushed forward as a payload propelled by the projectile rather than being pushed aside as would be the case with a more fluid, finely divided powder. Within the composition chamber (9) the coarse grains of the granulated pyrotechnic composition (4) as a whole form a semi-rigid structure, and consequently every granule is substantially supported on all sides by neighbouring granules. This factor also greatly reduces the fluid nature of the composition as a whole and compels any granulated pyrotechnic composition positioned in the path of an incoming projectile to more forward with the projectile rather than aside, thereby dramatically increasing the likelihood of energetic contact with the rear closure plate, and consequently the success of the target in terms of ignition reliability.

At the point of impact between the projectile and the rear closure plate (8) granulated pyrotechnic composition (4), carried forward by the momentum of the projectile, is therefore forcibly and energetically introduced and compacted onto the red phosphorus based surface coating (11). The resulting cross-contaminated admixture of red phosphorus and potassium chlorate contained within the red phosphorus based surface coating (11) and granulated pyrotechnic composition (4) respectively is then caused to react and ignite under the influence of energetic agitation, registering a "hit" with explosive feedback.

A further development depicted in Figure 2 includes a plurality of effects which enable the amplification of audible and visual effects for the determination of a successful "hit" at extended range. Whilst the method of preparation and principles of initiation are essentially identical to the target referred to in Figure 1, the target incorporates additional pyrotechnic effects which function as a result of ignition transfer from heat energy released, on combustion, by the granulated pyrotechnic composition (4). Within the body (2), an auxiliary chamber (14) is formed between the composition chamber (9) and the empty chamber (7). The chamber (14), sandwiched between the two neighbouring chambers, is formed between the inner walls of the body (2), the internal separator (3) incorporated in the construction of the composition chamber (9) and a second internal separator (16). The three chambers are preferably equal to one another dimensionally. An energetic pyrotechnic charge (15) is contained within the auxiliary chamber (14) and is so composed as to produce a visual and/or audible effect which, owing to the presence of potassium chlorate within the granulated pyrotechnic composition (4), must be segregated for both legal and safety reasons.

The energetic pyrotechnic charge (15) contrasts physically with the granulated pyrotechnic composition (4) in that it is deliberately finely powdered and comparatively fluid in nature. It typically occupies less than half the volume of the auxiliary chamber, and preferably only around a third of the chamber. When the target is struck by a projectile such as a bullet or air-gun pellet, the granulated pyrotechnic composition (4) is carried forward in the same way as previously described but propelled through the auxiliary chamber (14) and onto the red phosphorus based surface coating as previously described in the preceding example.

The fluid nature of the finely divided energetic pyrotechnic charge (15) ensures that the powder moves aside to permit relatively unhindered passage for both granulated pyrotechnic composition (4) and projectile alike. The openings created in both the internal separator (3) and the second internal separator (16) permit rapid ignition transfer throughout the whole target resulting in simultaneous ignitions in both the auxiliary chamber (14) and composition chamber

(9). The effect to an observer is a signature which is amplified both visually and audibly.

A third arrangement depicted in Figure 3 illustrates an alternative means of coupling a secondary pyrotechnic charge to the reactive element of the target and is particularly effective where a prolonged or greatly increased effect is desired. When the target face (19) is struck by a suitable projectile such as an air-gun pellet or bullet, the sequence of events leading to ignition is identical to that described for Figures 1 and 2. The target arrangement differs however in that ignition is then transferred laterally through the walls of the body (2) via a rapid transfer fuse (17) and into a surrounding auxiliary chamber (18) which houses a secondary pyrotechnic effect such as a smoke pellet (20). The smoke pellet (20) is caused to ignite from heat energy supplied by the rapid transfer fuse (17), generating smoke which is then released through the emission holes (21).

Alternative effects not shown on the illustration may include pyrotechnic sound units.

A fourth arrangement depicted in Figure 4 provides a means of increasing the reliability of the target by introducing an additional source of red phosphorus on a front closure plate (21) positioned on the underside of the front-face closure (1) with the phosphorus surface coating directed towards the granulated pyrotechnic composition (4). This arrangement effectively increases the chances of ignition by doubling the exposure of the granulated pyrotechnic composition (4) to a source of red phosphorus and provides an opportunity to employ the target in applications involving low energy projectiles such as air pistols and air-soft replica weapons.

CLAIMS

1. A pyrotechnic target, comprising a hollow body having first and second ends and containing at a first end thereof an internal surface bearing a layer of red phosphorus, a separator spaced from the first end to provide an air gap between the separator and the phosphorus layer, and a compartment between the separator and the second end, the compartment containing a quantity of pyrotechnic chemical material having deflagrating pyrotechnic characteristics, the body and the separator being formed of materials such that a projectile striking the second end will pass through the compartment and through the separator bringing the pyrotechnic material into contact with the red phosphorus layer with sufficient agitation to cause ignition of the pyrotechnic material.

2. A pyrotechnic target according to Claim 1, wherein the body, the air gap and the separator are such that a projectile striking the first end will carry red phosphorus through the air gap and the separator into the pyrotechnic material with sufficient agitation to cause ignition of the pyrotechnic material.

3. A pyrotechnic target according to Claim 1 or 2, wherein the pyrotechnic material is in granular form.

4. A pyrotechnic target according to Claim 3, wherein the grain size of the pyrotechnic material is greater than 1.0mm.

5. A pyrotechnic target according to Claim 3 or 4, wherein the grains are irregularly shaped whereby to promote the formation of voids between the grains.

6. A pyrotechnic target according to any preceding claim, wherein the pyrotechnic material comprises a chlorate.

7. A pyrotechnic target according to Claim 6, wherein the chlorate is potassium chlorate.

8. A pyrotechnic target according to Claim 6 or 7, further comprising potassium benzoate.

9. A pyrotechnic target according to Claim 6, 7 or 8, wherein the particle sizes of the solid components of the pyrotechnic material prior to granulation do not exceed 100 microns.

10. A pyrotechnic target according to any of Claims 6 to 9, further comprising resorcinol resin as a binder for the solid components.

11. A pyrotechnic target according to any preceding claim, comprising a second separator defining between the compartment and the second end a second air gap, and wherein a second layer of red phosphorus is provided on the underside of the second end.

12. A pyrotechnic target according to any preceding claim, wherein the or each layer of red phosphorus includes an adhesive to attach the phosphorus to the surface.

13. A pyrotechnic target according to Claim 12, wherein the adhesive comprises shellac.

14. A pyrotechnic target according to any preceding claim, wherein an auxiliary separator is positioned between the compartment and the first end, and spaced therefrom, to define a second compartment, the second compartment containing a second pyrotechnic charge adapted to produce a different visual and/or audible effect on ignition from the material in the first compartment.

15. A pyrotechnic target according to Claim 14, wherein the second pyrotechnic charge comprises a flash powder.

16. A pyrotechnic target according to Claim 14 or 15, wherein the second pyrotechnic charge is in the form of a flowing powder occupying a minor part of the second compartment.

17. A pyrotechnic target according to any preceding claim, wherein the body is mounted within and projecting from an enclosure containing at least one further pyrotechnic charge, at least one fuze extending from the air gap through the body to cause ignition of the or each further pyrotechnic charge when the pyrotechnic material in the body is ignited.

18. A pyrotechnic target according to Claim 17, wherein at least one further pyrotechnic charge is provided which generates smoke.

19. A pyrotechnic target according to Claim 17 or 18, wherein at least one further pyrotechnic charge is provided which generates noise.

20. A pyrotechnic target, substantially as described with reference to, and/or as shown in, any one of the drawings.

Application No: GB0913825.6 **Examiner:** Mr Jason Scott

Claims searched: 1-20 **Date of search:** 7 December 2009

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	GB 1263522 A WALTER ARTHUR FOGES See whole document.
A	-	GB 2454863 A AERIAL TARGET SYSTEMS See whole document
A	-	WO 02/35175 A AERIAL TARGET SYSTEMS See whole document and especially page 4, ll 8-17.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

C06B; F41J; F42B

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
C06B	0045/16	01/01/2006
F41B	0009/00	01/01/2006
F41J	0005/24	01/01/2006
F41J	0009/16	01/01/2006