(12) UK Patent (19) GB (11) 2609552 (13) B

(45) Date of B Publication 25.10.2023

(54) Title of the Invention: Multipurpose warhead

(51) INT CL: ***F42B 12/76*** (2006.01) ***F42B 12/22*** (2006.01) ***F42C 19/00*** (2006.01)

(21) Application No: **2209373.6**

(22) Date of Filing: **27.06.2022**

(30) Priority Data:
(31) **2109254** (32) **28.06.2021** (33) **GB**

(43) Date of A Publication **08.02.2023**

(56) Documents Cited:
GB 2142124 A
GB 1605340 A
US 3677181 A
US 20130239837 A1

(58) Field of Search:
As for published application 2609552 A viz:
INT CL **F42B, F42C**
Other: **WPI, EPODOC**
updated as appropriate

Additional Fields
Other: **None**

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GB 2609552 B

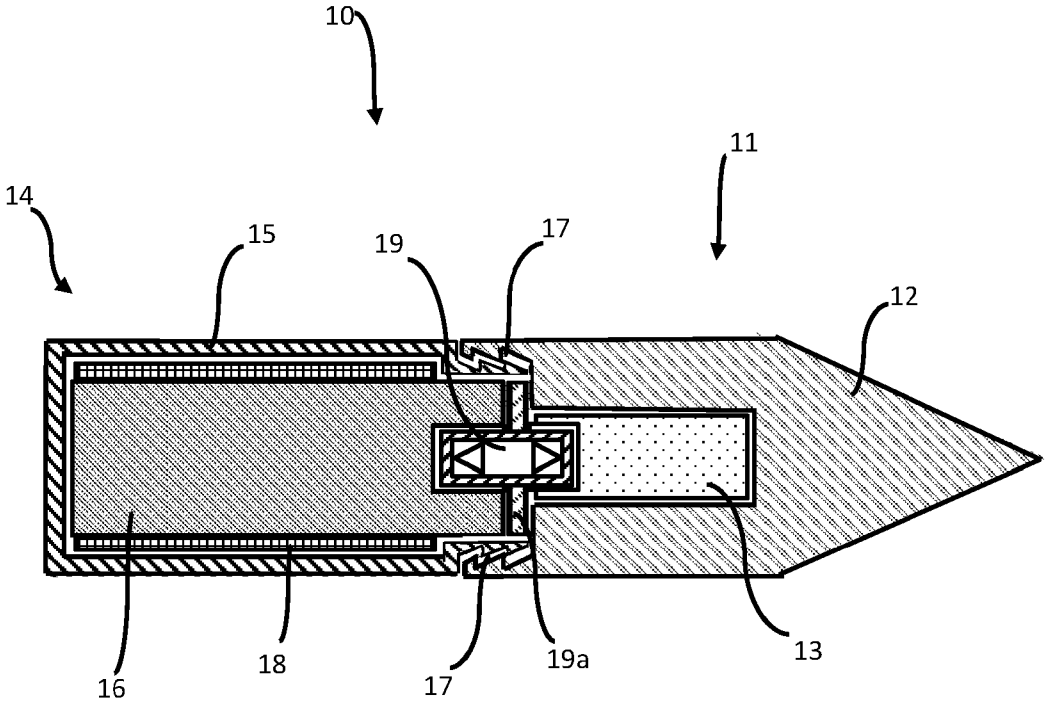

Figure 1a

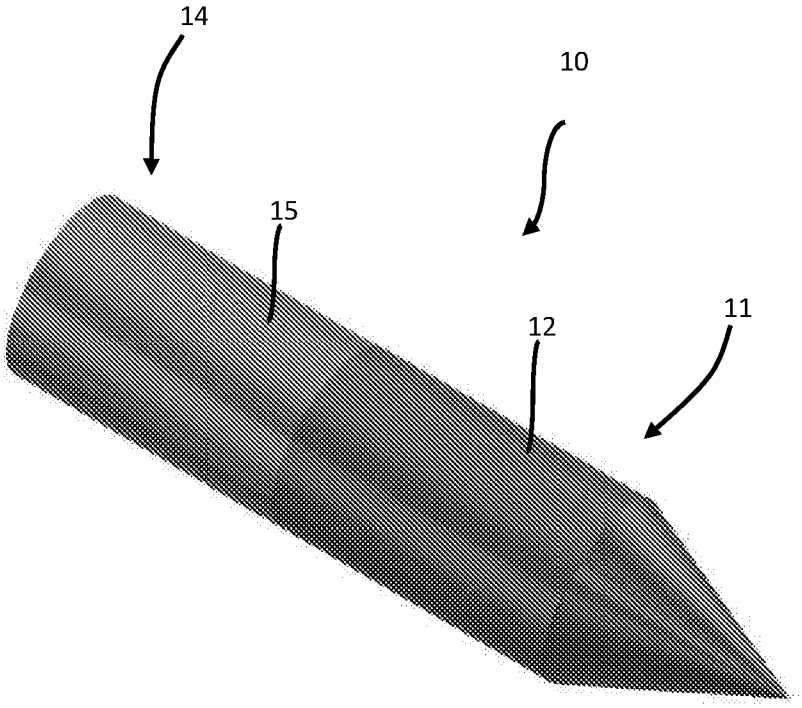

Figure 1b

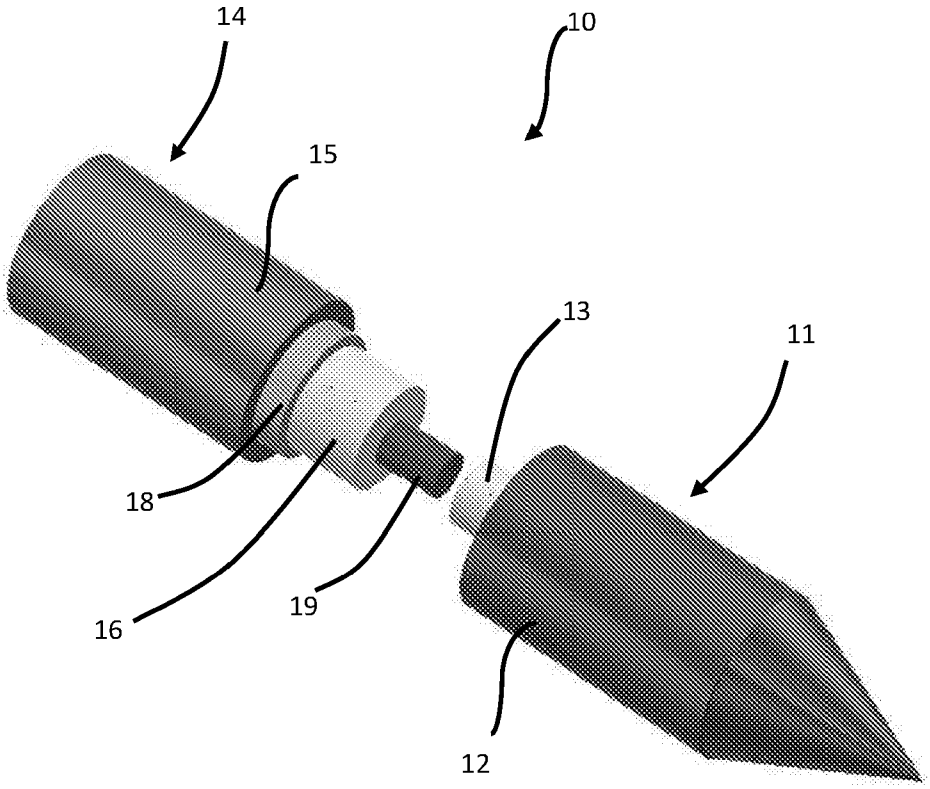

Figure 1c

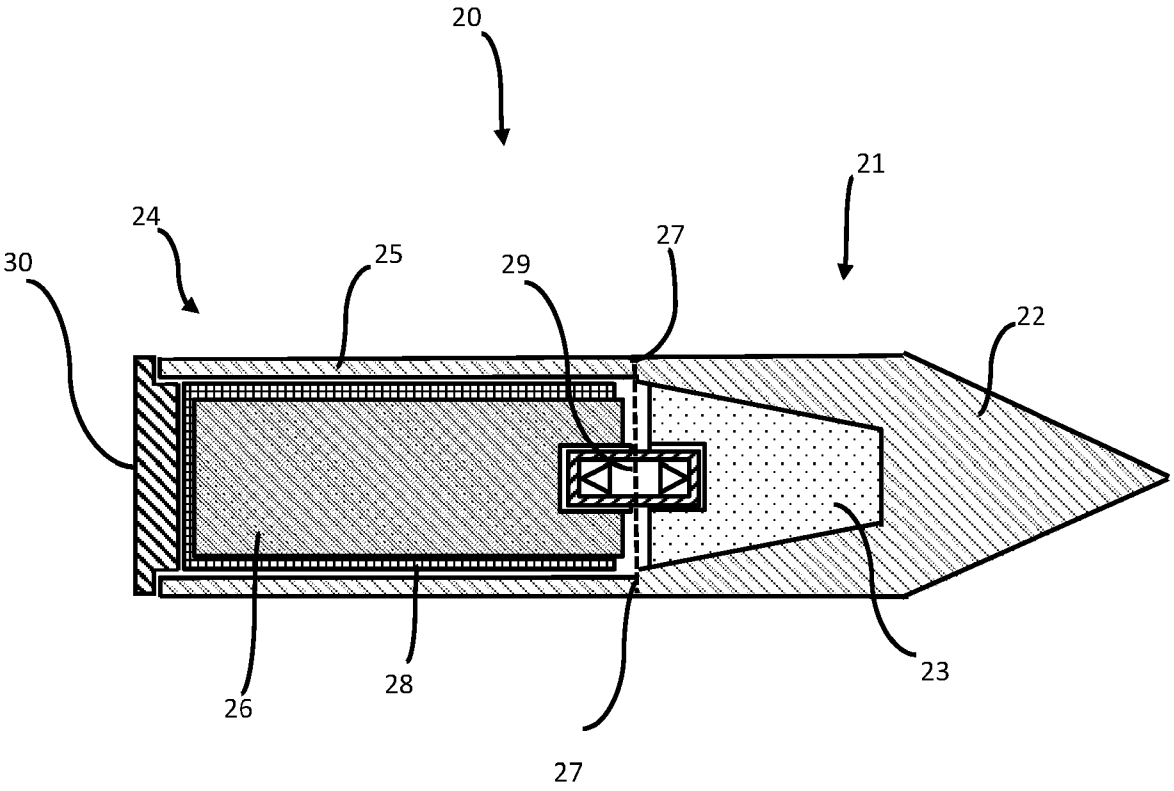

Figure 2a

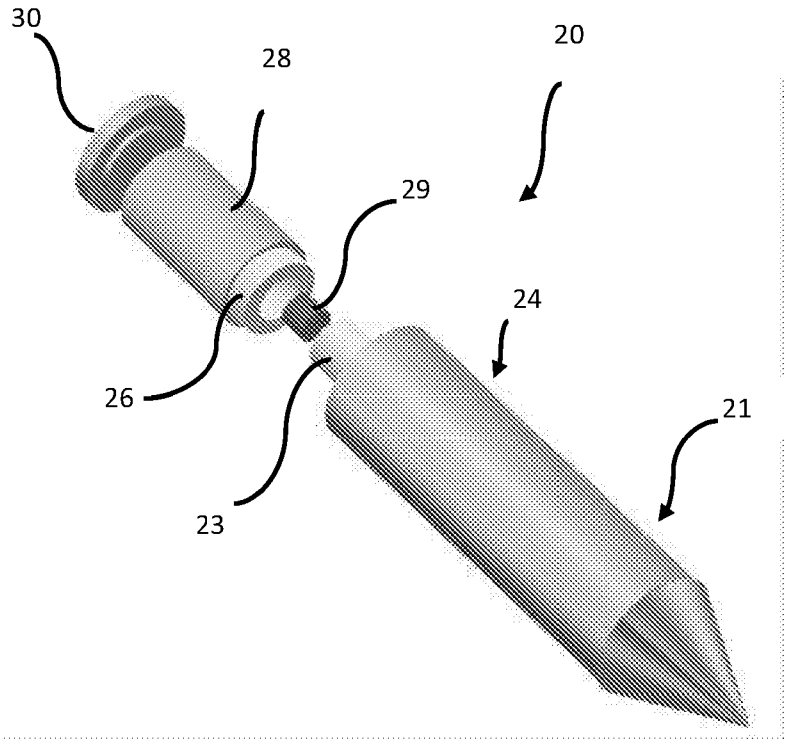

Figure 2b

MULTIPURPOSE WARHEAD

Technical Field of the Invention

This invention relates to the field of warhead design and particularly to the design of a multipurpose warhead.

Background to the Invention

A multipurpose warhead is a single warhead which can provide utility against a number of target sets. The benefit of these systems is to deliver an effect in the most efficient means possible, namely in a single payload or warhead.

A warhead conventionally consists of a structural outer case, typically, but not exclusively metallic for example steel, titanium, aluminium, as well as alloys, in addition other materials may be used such as polymers or composite materials. This casing surrounds an inner volume filled all or partially with explosive material which may also be selected according to the desired terminal effect(s). The outer casing fulfils a number of functions including but not limited to providing confinement for the explosive; structural rigidity; storage, launch, transit and impact survivability; protection from incidental or deliberate damage; and material for fragmentation. Warheads are typically shaped to optimise penetration of a target. As such they typically have a forward section shaped to be frustoconical, ovoid, ogive, concave or other suitable shape and typically have a substantially cylindrical aft or rearward end such as to provide internal volume, strength and to aid launch and integration into weapon systems. Further to this a warhead contains a means of fuzing, initiating and detonating the explosive material.

The selection of the casing material is driven by the required effect and target set of the warhead. Multi-purpose weapons in particular are challenged by the need to deliver effects against the broadest possible set of targets with a single warhead, and within the associated mass, volume and size constraints typical of these systems. Target sets for such warheads can

be described in many different ways, but within the art two examples are 'hard targets', commonly understood to include concrete reinforced structures such as a 'bunkers', and 'soft targets', which may be understood to include lightly armoured vehicles and personnel. For a multipurpose warhead the target set may include both hard and soft targets, which have different requirements to achieve effective prosecution.

To defeat 'hard targets' the warhead may need to penetrate a depth of concrete or armour. In order to increase penetrative depth it may be necessary to increase the casing thickness or material density, such that the ratio of explosive mass to warhead metal mass, known as the Charge to Metal ratio (C/M), will typically be reduced. Conversely to achieve maximum effect against a soft target, there is minimal requirement for penetration but maximum explosive and fragmentation effect is required to ensure that fragmentation is effectively distributed both in terms of spatial extent (area or volume) and velocity. Therefore, to defeat 'soft targets' the warhead is likely to be more effective at a high explosive mass to warhead metal mass ratio (charge to metal ratio C/M).

As such the problem exists to create an effective multipurpose warhead, suitable for use against a diverse target set, within the associated constraints of weapon size, volume and mass.

Therefore it is an aim of the present invention to provide a multipurpose warhead for improved performance against a range of target types.

Summary of the Invention

According to a first aspect of the invention there is provided a multipurpose warhead comprising an outer casing, explosive material housed within the outer casing and detonation means for detonating the explosive material, the warhead comprising a first section and a second section wherein the outer casing of the first section has greater strength than the outer casing of the second section and wherein the explosive material

comprises a first charge within the first section and a second charge within the second section, such that in use the first section impacts a target first.

A warhead is generally understood to be an explosive component of a weapon system. A weapon system may include a carrier or vehicle such as a missile or rocket, which carries a payload including a warhead which delivers the target effects. These carrier vehicles come in numerous types and sizes, optimised for the size of the payload, required target effects and the particular launch platform or vehicle such as fighter aircraft, naval vessel or land platform. Such optimisation is complex and has led to the development of many specialist warheads, which by definition, have the disadvantage of only being suitable for specific narrow target sets. This means that there is increased cost and logistic burden in using these weapons, especially when considering the impact of using a warhead against a target for which it has not been optimised. The current invention mitigates this disadvantage by providing a 'multipurpose warhead'. In this context 'multipurpose warhead' is intended to mean a single warhead which can be effective against multiple, distinct target types. Two such target types which present significant technical challenge are those of 'hard' and 'soft' targets.

The inventor has identified that the effectiveness of a warhead against multiple targets including 'hard' and 'soft' targets can be greatly improved with a new warhead design. The multipurpose warhead is designed with an outer casing having a first or forward section and a second or rearward section. Within this context the first section is the section which would impact the target first and be the most forward section when deployed. The first or forward section and second or rearward section are capable of taking up different proportions of the overall warhead body volume to enable flexibility in the configuration of the warhead, and can be joined directly or by any number of intermediary sections.

In accordance with the invention the outer casing strength of the first and second sections are different, with the first section having a greater strength than the second section. 'Strength' in this context relates to the material properties selected for the warhead, which within typical materials used within the art, such as metals alloys or composite materials,

strength could relate to properties such as the tensile strength, impact strength or yield strength, as well as material properties such as thickness or density. For example the outer casing of the forward or first section could be formed having a minimum thickness of around 25mm and the second or reward section of the casing having an average thickness of around 12.5mm. An advantage to having an outer casing with a first or forward section with a greater strength is to ensure that the warhead can deliver the penetrative effects required of this type of warhead. A further advantage of having differing case strengths is that the casing strength of the second or rearward section can be reduced to that which is a practical minimum to enable the warhead to fulfil its function in providing confinement for the explosive; structural rigidity; storage, launch, transit and impact survivability; protection from incidental or deliberate damage; and material for fragmentation. This in turn helps in circumstances where there are mass constraints for a given warhead design, as more of the mass can be utilised for alternative aspects of the design. For example to allow for additional mass of the forward section outer casing, increased mass of explosive fill within the overall warhead, also referred to as charge-to-metal ratio, or any other payload considerations such as the integration of sensors or communications devices.

The use of explosive fill within a warhead is well known in the art to deliver additional effects or damage on the target, for example through blast and fragmentation. In accordance with the invention, there is a first explosive charge and a second explosive charge and a detonation means housed within the casing. The charges may be positioned within the casing in different configurations such as to achieve the effects required to defeat different target sets, additionally multiple charges could be added, to further modify the performance characteristics of the warhead. These effects may include blast, fragmentation or both. The detonation means may include any such device or method known to the art for detonating the explosive material, which may further refer to terms such as, initiator or fuze. Detonation may by triggered or initiated by a fuze operating by timer, remote means, contact, altitude, proximity or combinations of these or other known fuzing or initiation means. The detonation means is configured such that either or both the first and second explosive charge may be detonated. This provides the advantage that the warhead can

deliver a range of effects dependant on how the detonation means is configured to operate in use, for example by detonating the first, second or both charges.

Existing generic single weapons have the disadvantage of not being optimised for any particular target set. Alternatively, the need to pre-select a weapon to suit a particular target type has the disadvantage of requiring increased stockpile of weapons, as well as the associated cost of qualifying multiple weapons for use. Advantageously the invention allows for a single warhead to be qualified, for example for air, maritime or ground launch, and to provide optimised effects against multiple target sets. For example the multipurpose warhead will be effective against either a 'hard' or 'soft' target or a combination of the two. In one embodiment the properties of the multipurpose warhead casing having a first section and second section and explosive charge ensure that the warhead is effective against multiple targets including both 'hard' and 'soft' targets.

In other embodiments the performance of the multipurpose warhead can be further optimised by selecting 'detonation modes'. In this context 'detonation modes' refers to how the explosive charge in the warhead is detonated, namely that the first, second or both charges are detonated, but may also include the use of any fuzing or initiation means known known in the art. The 'detonation modes' advantageously provide the multipurpose warhead with additional utility.

Furthermore in a circumstance where the target has elements of both 'soft' and 'hard', for example a reinforced building, the multipurpose warhead allows for both penetration of the building and then blast and fragmentation effects inside of the building by varying the 'detonation mode'. Additionally, a further advantage of the invention is that it provides a level of redundancy to the warhead, when in use, such that should either charge fail to detonate the other can provide some effect.

In certain embodiments of the invention the greater strength of the outer casing of the first section is provided by it being thicker than the outer casing of the second section. In some embodiments the outer casing of the first section may have a uniform casing thickness,

alternatively it may have a casing thickness profile which varies by positon longitudinally, circumferentially or both across the outer casing. Preferably the first or forward casing thickness profile is configured to deliver the penetrative (and where relevant aerodynamic) effects required. Typically this is achieved through shaping the forward section to have largely a frustoconical, ovoid, ogive, concave or any other suitable shape. Shaping of the casing also provides an internal volume which can be utilised for other aspects of the warhead design including the explosive material fill. The relatively reduced thickness of the second or rearward casing may similarly be uniform or varied by position longitudinally, circumferentially or both across the outer casing. Typically the rearward section may be largely cylindrical in shape, but could equally be shaped, for example, to continue the profile of the forward section. This advantageously allows for the outer casing of the rearward section to have different properties to that of the forward section, for example a different charge-to–metal ratio. Typically an enclosed volume is created by the outer casing and a closing surface at the rear of the warhead.

In some embodiments of the invention the greater strength of the outer casing of the first section is provided by it comprising a stronger material than the outer casing of the second section. The material for the first or forward section outer casing may be selected from any typical materials used in warhead design, for example metals, alloys and composites. Preferably the outer casing of the forward section is made from a material suitable for withstanding the forces expected in-use. This includes being able to withstand the launch or release of the warhead as well as any intended impact against a specified target. For example against a 'hard target' it may be desirable to use a material with a high strength to weight ratio such as steel or other materials with a suitable strength to weight ratio. The material should also be chosen such that it can be machined or manufactured into the appropriate shape for example being largely a frustoconical, ovoid, ogive, concave or any other suitable shape, whilst also leaving a void or cavity internal to the casing to allow for explosive material, fuzes, sensors, communication devices or any other elements of warhead design. Furthermore the material may be selected to provide specific performance attributes such as being able to generate fragments, either naturally forming, or preformed as part of the manufacturing process, as part of the outer casing or as part of an internal

layer within the internal volume of the casing. Preferably the material for the second or rearward section should be selected so as to enable the warhead to fulfil its function in providing confinement for the explosive; structural rigidity; storage, launch, transit and impact survivability; protection from incidental or deliberate damage; and material for fragmentation. The material may be selected from the same typical materials as the forward section such as metals, alloys and composite materials, but advantageously can be selected to be a different material to that of the forward section outer casing, such as to have different material properties, namely reduced strength to that of the forward section. This has the advantage that the material for the rearward section outer casing can be selected, for example to be lower density then the forward section, which for a given volume reduces the overall mass. This has the advantage that under the constraints of mass or volume within a warhead design there is greater flexibility to optimise the warhead for different weapon effects. Further to this the selection of the material for the outer casing of the rearward section may also allow for a lower cost material to be used, or a material that can be readily mass produced.

In some embodiments of the invention the outer casing of the first section and the outer casing of the second section comprise separately constructed parts fixedly attached to each other. This advantageously allows for the outer casing of the first or forward section and outer casing of the second or rearward section to be manufactured independently, for example from differing materials or utilising different manufacturing or production techniques, which allows for the optimisation of the multipurpose warhead wherein the forward and rearward sections can be designed for a plurality of target sets. A further advantage is that the sections of the outer casing can be filled, for example with explosive material using standard methods prior to being fixedly attached, allowing differing explosive materials, or volume of explosive material to be used in the forward section to that of the rearward section. The forward section or rearward section may be fixedly attached by any known means suitable to the materials of the outer casing, such as fasteners, clamps, brackets or threaded means, in addition to other known fixing methods such as friction fitting or use of a bonding material or media. Furthermore the forward and rearward sections may be fixedly attached directly to each other or via a plurality of intermediary sections.

In some embodiments of the invention the outer casing of the forward section and the outer casing of the rearward section are of unitary construction. This advantageously allows for the production of a warhead utilising typical manufacturing or machining techniques including additive manufacture, which would allow for the warhead to have a forward casing section and rearward casing section of differing strengths, for example by changing the thickness of the casing material or material type through machining or the laying down, depositing or casting of material to form the warhead casing. The outer casing may be manufactured such that the casing substantially provides the containment to the internal volume, providing an open end, the outermost end, preferably of the reward section, such that the internal volume can be filled with the explosive material, and detonation means, or any other payload such as sensors, or communication means and subsequently be closed or capped by suitable material and methods. A further advantage of this is that the outer casing can be formed to have no externally visible delineation between the forward and rearward section providing improved and more easily predictable aerodynamic performance, as well as providing no visual clue as to the internal design of the warhead.

In some embodiments of the invention the outer casing is provided with a pre-manufactured casing weakness between the first and second sections such that the first or forward section and second or rearward section can separate in use. Advantageously this allows for the separation of the warhead at a predesigned point in the casing. The weakness may be varied to suit the requirements of the warhead such that the sections may 'break' under different types, for example strain or impact, and level or magnitude of force. The weakness may be achieved by providing a weakened bond between the outer casing forward section and outer casing rearward section, or reducing the strength of the material during or post manufacture by any typical process such as milling or machining. This may be applied externally to the warhead casing but is preferably internal to the casing such that the external profile is unaltered. The casing weakness may also be achieved by inserting an intermediary casing section between the outer casing forward section and outer casing rearward section. The casing weakness may further be achieved using a mechanical or electromechanical clamp, clasp or fixing method able to operate under predefined

conditions such as impact or strain such that the bond is released. A further benefit of providing a pre-manufactured casing weakness is to ensure that should the casing fail under impact forces it does so in a predetermined way such that the effects of the warhead are predictable. A further advantage is to ensure that any break occurs in such a way as to allow for the detonation means to function either completely or partially. Additionally the weakness can be manufactured such that in use the warhead can separate such that both the forward section and rearward section can still operate. For example, when the warhead hits a 'hard' target the forward section continues to penetrate the target whilst the rearward section separates to deliver blast and fragmentation effects external to the 'hard' target.

In some embodiments of the invention the detonation means may comprise a single, double ended detonator configured to detonate either or both the first and second charges. The detonation means may include any such device or method known to the art for detonating the explosive material, which may further refer to terms such as, initiator or fuze. Detonation may by triggered or initiated by a fuze operating by timer, remote means, contact, altitude, proximity or combinations of these or other known fuzing or initiation means. The detonation means is configured such that the first explosive charge and the second explosive charge or both may be detonated. This provides the advantage that the warhead can deliver a range of effects dependant on how the detonation means operates in use, referred to as the 'detonation mode', for example by detonating either or both the first and second charges. Additionally a further advantage to the detonation means is that it provides a level of redundancy to the warhead when in use, as the means for detonation is able to operate if the warhead is damaged or, for example in some embodiments breaks along the pre-manufactured weakness. The detonation means may be held directly within the explosive material or be placed in a suitable clamp, bracket or holder within the volume of the warhead. Furthermore the securing means may also provide additional confinement to the explosive material, such that in use, under the circumstances when the warhead separates along the pre-manufactured weakness, the first and second explosive charge and detonator remain intact and function as intended. Alternatively the confinement may be

provided by additional material placed between the forward and reward section such as to form two distinct volumes adjacent the detonation means.

In some embodiments of the invention the detonation means comprises two detonators configured to separately detonate the forward and rearward charges. Advantageously this allows for the use of simpler, potentially lower cost single detonation means common in the art. A further advantage is that the detonation means may be positioned within the warhead body at any location such as to detonate the forward explosive charge and rearward explosive charge. A further advantage is that the detonation means can be independently configured.

There are a number of approaches to manufacturing the invention with examples having been provided; as separate forward section and rearward section sub-assemblies or alternatively as a unitary construction. However other methods such as manufacturing a casing in two halves along the longitudinal axis resulting in a forward section and rearwards section, should also be considered as part of the scope of this invention.

According to a second aspect of the invention there is provided a weapon system comprising the multipurpose warhead of the first aspect. It will be apparent to the skilled person that the multipurpose warhead can be integrated into a range of weapon systems to deliver the benefits described herein.

Brief Description of the Drawings

Embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1a illustrates a cross sectional view of an embodiment of a multipurpose warhead;
Figure 1b illustrates a perspective view of the embodiment of Figure 1a;
Figure 1c illustrates an exploded perspective view of the embodiment of Figure 1a;
Figure 2a illustrates a cross sectional view of an alternative embodiment of a multipurpose warhead; and
Figure 2b - illustrates an exploded view of the embodiment of Figure 2a.

Detailed Description

Figure 1a-1c show illustrations of one embodiment of the multipurpose warhead 10. Figure 1a shows a cross sectional view of the invention, through the longitudinal axis, which passes symmetrically through the centre of the warhead 10, with a first or forward section 11, and second or rearward section 14. The forward section outer casing 12 has a conical nose section and cylindrical body. The forward section outer casing 12 is made of steel machined to form the outer shape and internal volume which provide three sides of containment for the forward explosive charge 13 formed from a high explosive material. The rearward section outer casing 15 is cylindrical and provides three sides of containment for the internal volume. It has been machined from a thinner steel to that of the forward section outer casing 12, such that the forward section 11 and rearward section 14 have different casing strengths. The internal volume of the rearward casing holds the rearward explosive charge 16 formed from a high explosive material. In this embodiment the rearward explosive charge 16 is of greater volume than the forward section explosive charge 13, meaning that the rearward section 14 has a greater charge-to-metal-ratio then the forward section 11. Between the rearward outer casing 15 and the rearward explosive charge 16 there is a preformed fragmentation layer 18, made from tungsten which adds to the natural fragmentation formed by the casing when the rearward explosive charge is detonated, further enhancing the utility as a multipurpose warhead. The detonation means 19 is a

single double ended detonator capable of detonating the forward explosive charge 13 and the rearward explosive charge 16, when triggered by the fuze (not shown). The detonation means 19 is held in place by a reinforced annulus 19a, this additionally provides confinement for the forward explosive charge 13. The forward outer casing 12 and rearward outer casing 15 are joined by a threaded joint 17. In this embodiment of the invention the threaded joint 17 additionally provides the pre-manufactured weakness in the outer casing, such that in-use the warhead may 'break' along the threaded joint 17 safeguarding the functionality of the forward section 11, rearward section 14, detonation means 19 and forward charge 13 and reward charge 16. Figure 1a further shows how the forward explosive charge 13 is conformal to the inner volume of the forward outer casing 12. Similarly the rearward explosive charge 16 is conformal to the rearward outer casing 15 as is the preformed fragmentation layer 18, furthermore it illustrates how the forward explosive charge 13 is of reduced volume to that of the rearward explosive charge 16 due to the differing casing thickness of the forward outer casing 12 and rearward outer casing 15. Figure 1b shows a perspective view of the multipurpose warhead 10, showing the forward outer casing 12 differently shaded to that of the rearward outer casing 15 and illustrating that externally there is minimal break in the surface of the casing where the two sections join. Figure 1c shows the invention 10 in exploded view. The detonation means 19 is shown central to the longitudinal axis and when held in an annulus (not shown) would be received by a suitable hollow or void in the explosive material of both the forward explosive charge 13 and rearward explosive charge 16.

Figure 2a-2b show an illustration of a second embodiment of the invention wherein the casing is made from a single piece of steel. Figure 2a shows a schematic cross-sectional view of the warhead 20, through the longitudinal axis, that which passes symmetrically through the centre of the warhead 20, with a first or forward section 21, and second or rearward section 24. The forward section outer casing 22 has a conical nose section and cylindrical body, wherein the casing thickness is varied longitudinally. Although the outer casing is of one continuous piece the forward section 21 and rearward section 24 are delineated by the pre-manufactured line of internal weakness 27. The rearward section 24 has a casing 25 which is cylindrical in shape being formed as part of the same process as the forward section outer casing 22, however having a much reduced, and uniform thickness. The forward

charge 23, detonation means 29, preformed fragmentation layer 28 and rearward charge 26 are shown within the warhead internal volume and can be inserted through the open rearward end of the warhead which is then closed with the end cap 30, made of steel to enable simple fixing through threaded means (not shown). Figure 2b shows an exploded view of the embodiment 20, showing the forward charge 23, detonation means 29, rearward explosive charge 26, preformed fragmentation layer 28 and end cap 30. There is no externally visible delineation between the forward section 21 and rearward section 24 in this embodiment as the outer casing is formed as a single piece.

In use, the multipurpose warhead 10, comprises a first section 11, and second section 14. When engaging a 'soft target' the warhead 10 may fully penetrate the target without breaking along the pre-manufactured weakness 17 delivering the full payload into the target. Alternatively the warhead may be detonated such as to utilise the natural fragments of the outer casing and the preformed fragmentation layer 18 of the reward section 14, on or external to, a target. When impacting a 'hard target' the warhead 10 may break along the pre-manufactured weakness 17 ensuring that the first section 11 may efficiently penetrate the target without the performance being affected by the second section 14 which can breakaway. Furthermore the functionality of the forward charge 13 and detonation means 19 is additionally protected by the securing means 19a, which acts to hold the detonation means 19 and forward charge 13 in place, ensuring the explosive performance of the warhead.

CLAIMS

1. A multipurpose warhead comprising an outer casing, explosive material housed within the outer casing and detonation means for detonating the explosive material, the warhead comprising a first section and a second section wherein the outer casing of the first section has greater strength than the outer casing of the second section and wherein the explosive material comprises a first charge within the first section and a second charge within the second section, such that in use the first section impacts a target first.

2. The multipurpose warhead of claim 1 wherein the outer casing of the first section is thicker than the outer casing of the second section.

3. The multipurpose warhead of any one of claims 1-2 wherein the outer casing of the first section comprises a stronger material than the outer casing of the second section.

4. The multipurpose warhead of any preceding claim wherein the outer casing of the first section and the outer casing of the second section comprise separately constructed parts fixedly attached to each other.

5. The multipurpose warhead of any of claims 1-3 wherein the outer casing of the first section and the outer casing of the second section are of unitary construction.

6. The multipurpose warhead of any preceding claim wherein the outer casing is provided with a pre-manufactured casing weakness between the first and second sections such that the first section and second section can separate in use.

7. The multipurpose warhead of any preceding claim wherein the detonation means comprises a double ended detonator configured to detonate either or both the first and second charges.

8. The multipurpose warhead of any of claims 1-6 wherein the detonation means comprises two detonators configured to separately detonate the first and second charges.

9. A weapon system comprising the multipurpose warhead of any preceding claim.