United States Patent Office references to conventional guided weapons with suspected Uranium warhead components

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Tables A and B summarise US Patents with references to weapons systems known or suspected to contain Uranium warhead components. They include extracts from public domain records on the US Patent Office database at http://patft.uspto.gov.

Searches can also be made through **esp@ace.net** at http://gb.espacenet.com/espacenet/gb/en/e_net.htm?search5 . Further details of the patents listed below are available by searching these sites by Patent Number. Direct file links are not available.

Ongoing research

These extracts are the latest findings from ongoing research into the proliferation of Uranium warheads in "conventional" guided weapons - guided bombs, cruise and other guided missiles and sub-munitions. Enquiries started in January 2001 but the secret "dense metal" used in 23 suspected systems has been hard to verify. Until now its identity has been concealed by vague data from military and manufacturers' sources and denial or misleading responses to enquiries by the US and UK governments (refer **DU weapons 2001-2002*** pages 52-57).

These extracts are selected from the most obvious US patent records. Further research is needed including patents for other weapons and in other countries. Some Internet sources have become less informative or have removed detailed specifications of suspected Uranium weapons since the start of bombing in Afghanistan in October 2001.

Notes

US Patent 6389977 (**Shrouded Aerial Bomb**) clearly identifies **Depleted Uranium** as an intended design option for the hard target guided bombs most widely used in Afghanistan - upgraded versions of the 2,000 lb BLU-109/B hard target warhead with the AUP-116 advanced penetrator. These include versions of the GBU-15, 24 and 31 and the AGM-130C.

Patent 6389977 verifies Conclusion 1 in Depleted Uranium weapons 2001-2002 (page 129)* that some Advanced Penetrator warheads are designed to use Uranium as the main warhead casing or ballast.

The other patents listed in Table A indicate Uranium or Depleted Uranium as a viable design option to Tungsten **in other penetrator and shaped charge warheads and submunitions**. When Tungsten and other metals are compared for tactical effectiveness (high density and incendiary effects) and cost there is a high probability that Uranium (depleted or undepleted) has been chosen as the most cost effective combat option, despite comments recognising its health and environmental hazards.

The US Patents listed in Table B are relevant for analysts investigating weapons systems and warhead technologies that may use Uranium components or where it may be substituted with non-radioactive materials.

This search did not include patents for the use of Uranium in anti-armor penetrator ammunition, nor in nuclear weapons. Some numbers in the descriptions refer to diagrams in the original patent documents.

Further Information

Technical descriptions of some weapons using these patents are on the Federation of American Scientists (FAS) website at http://www.fas.org/man/

Items marked * are identified in **DU weapons 2001-2002** (January 2002), available online in PDF format at http://www.eoslifework.co.uk/du2012.htm or in hard copy or CD-ROM versions from Politicos Bookshop, London.

The implications of Uranium warheads in cruise missile and guided bombs for proposed military action against Iraq are considered in **Hazards of uranium weapons in the proposed war on Iraq** (September 2002), summary and full report at http://www.eoslifework.co.uk/u23.htm

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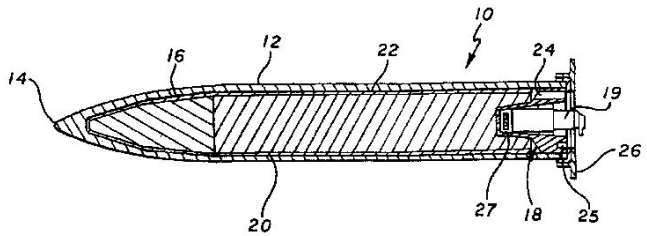
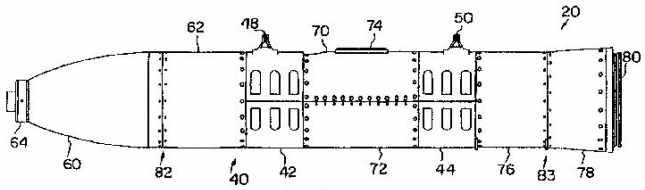
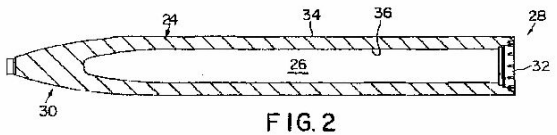
Table A: US Patents with direct references to Uranium or Depleted Uranium (DU)

US Patent Number	Date	Title and extracts from patent specifications	Inventor	Assignee/Organisation & comments
4,638,737	June 28, 1985	**Multi-warhead, anti-armor missile** A missile for defeating active armor[1] of a target as set forth in claim 3, wherein said primary warhead is made of a heavy metal selected from tungsten carbide and **uranium ore** A multi-warhead, anti-armor missile in accordance with this invention for defeating shielded armor of the type described above includes missiles 10a and 10b in FIGS. 2 and 3 each of which have two warhead sections. Missile 10a has a shaped charge main warhead (16) and missile 10b **has a heavy metal type main warhead** (18) **which is made of a material such as tungsten carbide or depleted uranium** that is designed to deliver a concentrated blow to the main armor of an armored vehicle. Missiles 10a and 10b each have secondary warheads (20) as illustrated **with a multiplicity of a depleted uranium or tungsten carbide flechettes** (22) that are mounted in holders for deployment and enclosed by nose cone sections (26). The secondary warhead includes a multiplicity of subcaliber kinetic energy warheads (22) as illustrated in FIGS. 2, 3 and 4 and these subcaliber warheads are preferably kinetic energy warheads that are referred to as flechettes and are **made of heavy material such as depleted uranium or tungsten carbide** --- [1] ***Active armor*** *also known as explosive reactive armor - an extra layer of armor plates with small explosive charges. When hit by a projectile the explosive blows off the plate deflecting the attack. Double warhead systems trigger the active armour with a small initial impact (in this case flechettes), followed by a main attack charge or penetrator.*	McIngvale	US Army Example of anti-tank missile development for the US Army in the 1980's using Uranium warhead components. This system has not been identified but the TOW and Maverick missiles used extensively in the Gulf War (Desert Storm) 1991 had heavy metal warhead and shaped charge warhead options. (DU weapons * pages 82-3 & 88). Investigation of suspected Uranium warhead must include anti-armor guided weapons operational since 1990 and re-calculation of total Uranium tonnage used in Iraq in 1991.

5,542,354	July 20, 1995	**Segmenting warhead projectile** The warhead of claim 2 wherein said first housing and said second housing are independently each selected from the group consisting of iron, steel, tungsten, tantalum**, depleted uranium and alloys thereof ...** Other metals useful for the frangible first housing include tungsten, tantalum, **depleted uranium and alloys thereof**.	Sigler	Olin Corp, California The segmenting warhead projectile is launched from any suitable apparatus such as a grenade launcher, for example, the M-203 and Mark-19 utilized by the U.S. Armed Forces.
5,691,502	June 5, 1995	**Low velocity radial deployment with predetermined pattern** The invention can be employed in an interceptor missile for the purpose of increasing the area of potential impact with a target. Each lethality enhancing object (28) is preferably fabricated from a dense metal. **While any suitable dense metal can be employed, metals having a density of at least 15 gm/cc are presently preferred, e.g., tantalum, tungsten, rhenium**, **uranium**, etc. The **higher densities** permit a greater mass in a given volume or the same mass in a smaller volume, thereby enhancing the impact force of a lethality enhancing object (28) while decreasing the surface area exposed to aerodynamic forces. A presently preferred lethality enhancing object (28) is formed of pressed sintered particles of ductile tungsten	Craddock, Graves	Lockheed Martin Vought Systems Corp, TX Ground to air missile weapon system not identified. Patent involves multi-layered warhead casing giving variable control over fragmentation characteristics. Relevant in advanced penetrator warheads where fragmentation affects incendiary potential if uranium is used in casings.

5,939,662	Dec 3, 1997	**Missile warhead design** [Tomahawk] **A hard-target penetrating warhead** (10) adapted for use with length constrained warhead payload bays. The warhead (10) includes a warhead case (12) for containing warhead explosives (22, 27). A tungsten ballast (16) is disposed within the case (12) for providing a high warhead sectional pressure upon impact of the warhead (10) on a target The case (12) is a 330 pound penetrating thick-walled case constructed of 4340 mod aircraft quality steel alloy. The special nose (14) is a 6 caliber radius head nose (6 CRH, an arc with a radius of 6 times the diameter of the warhead) designed for maximum warhead penetration. **The tungsten ballast 16 weighs approximately 240 pounds**, and in combination with the nose (14) results in very high warhead sectional pressure. The tungsten ballast (16) and the special nose (14) provide significantly more target penetration than existing warheads whose lengths are constrained by payload bays or other factors. **The ballast** (16) is constructed of tungsten IAW MIL-T-21014D CLASS 4 cast and machined into the appropriate dimensions. The ballast (16) was designed to maximize ballast effectiveness while minimizing costs, **however those skilled in the art will appreciate that other ballast shapes may be used** without departing from the scope of the present invention**.** **In addition, other ballast sizes and other materials such as lead or depleted uranium may be used without departing from the scope of the present invention.** 	Bootes	Raytheon, US Example quoted for Tomahawk, or other missiles carrying penetrator in a weapons bay. This appears to be the warhead patent for Raytheon's Tactical Tomahawk Penetrator Variant approved May 1999. (DU weapons * pages 87-88). The concept in this patent is transferable to other cruise missiles. Like several other patents listed in Table A this application describes Tungsten ballast but specifically includes depleted uranium as an alternative ballast option. The earlier WDU-36 Tomahawk (Block III) warhead first used in the Sept 1995 Bosnia strike was reported to use Depleted Uranium (Hooper 1999, Liolios, 2002).

6,389,977	Dec 11, 1997	**Shrouded Aerial Bomb** [BLU-109/B and variants] A target penetrating aerial bomb including a penetrating body shaped for improved target penetration, having a narrower impact profile at approximately the same weight as an existing bomb. An aerodynamic shroud encases the penetrating body and emulates the aerodynamic shape of the existing bomb, and the weight, center of gravity, and moments of inertia of the bomb closely approximate those properties of the existing bomb. The bomb constructed according to the present invention may be qualified by similarity to the existing bomb, thus avoiding lengthy and costly qualification procedures. Claims: 1. a penetrating body having a nose section shaped with an ogive and having a hollow bore with an opening at a tail end and extending toward the nose section; and an aerodynamic shroud mounted to an outer surface of the penetrating body, the shroud including means for securing the shroud to the penetrating body, wherein an aerodynamic shape of the shroud is substantially identical to an aerodynamic shape of a selected, qualified aerial bomb and the penetrating body and shroud have a weight, center of gravity, and moments of inertia substantially similar to a weight, center of gravity, and moments of inertia of said selected, qualified aerial bomb ... 4. The shrouded aerial bomb as claimed in claim 1, wherein the penetrating body is formed from tungsten. **5. The shrouded aerial bomb as claimed in claim 1, wherein the penetrating body is formed of depleted uranium.** The present invention relates to aerial bombs, that is, bombs dropped from aircraft, and more particularly, to **aerial bombs for penetrating hard targets**. / ... continued	Schmacker	Lockheed Martin Corp Bethesda This is definitive patent for the outer casing of the upgraded GUB-15, 24,27, 31 and AGM-130C warheads. The shroud contains the AUP-116 advanced penetrator. **This patent specifically identifies BOTH Tungsten AND Depleted Uranium penetrator versions**. See **USAF Mission Plan 1997** (DU weapons* pages 15-20). Also FAS website description of the GBU-24 2000 lb guided bomb with AUP-116 penetrator upgrade from BLU-109. (DU weapons* page 77).

		More particularly, the present invention provides a bomb having **an improved penetrating warhead**, that is, a warhead that more deeply penetrates a protected target, however, the bomb is substantially identical in aerodynamic and mass properties to a qualified [already patented] bomb. The bomb (20) includes a penetrating body (24) or warhead (shown in FIG. 2) and a shroud (40) shaped to emulate the aerodynamic shape of an existing, qualified bomb. In the exemplary embodiment, **the bomb (20) is shaped to emulate the BLU-109/B bomb**, that is, the outer shape of the shroud (40) is substantially identical to the outer shape of the hard case of the BLU-109/B. In addition, the weight, center of gravity, and moments of inertia of the bomb (20) are substantially identical to those physical characteristics of the BLU-109/B. It is understood that **the invention is not limited to a particular diameter or weight ratio as compared to an emulated bomb.** The diameter and weight of the warhead are to be selected, for example, for the penetrating and explosive functions desired, within the constraint of the total weight of the warhead and shroud being approximately equal to that of the emulated weapon.  FIG. 1  FIG. 2		

6,308,634	August 17, 2000	**Precursor-follow through explosively formed penetrator (EFP) assembly**. The precursor-follow through kinetic energy explosively formed penetrator assembly greatly enhances target penetration. It is formed of two sections: an initial precursor penetrator followed by a penetrator encapsulating a reactive material. The target will initially be perforated by the precursor penetrator with the second follow through penetrator containing a reactive material causing internal damage through a secondary reaction. **The material of choice for the liner (20) is iron, tantalum, copper, or material of like composition, or of metallic materials such as silver, tungsten, or depleted uranium**, or of other materials as described herein.	Fong	US Army Detailed description of explosively formed penetrators mainly for anti-armor guided weapons or submunitions e.g. the **BLU-108/B** anti-tank munition delivered in the **CBU-97** "**cluster bomb**". See FAS website and picture in DU weapons * page 91.
6,393,991	June13, 2000	**K-charge--a multipurpose shaped charge warhead** A multipurpose warhead utilizes a **shaped charge** device with a shaped charge liner having an included angle in excess of 70 degrees. sealing an internal cavity that contains an explosive. A detonator system having a selectable plurality of outputs contacts the explosive. Peripheral detonation of the explosive generates a high speed, small diameter, penetrating jet that typically includes about 90% of the liner mass. Central point source detonation of the explosive generates a larger diameter, slower moving, explosively formed penetrator. A combination of plural peripheral point detonation and central point source detonation generates multiple fragments. An ability to select detonation type in the field enables a single warhead to be effective against multiple target types. The shaped charge liner may optionally be a composite material having a jet forming portion and an effect forming portion The **shaped charge liner** (18) is formed from a ductile metal or metal alloy and is typically copper. **Other metals that have been disclosed as useful for shaped charge liners include nickel, zinc, aluminium, tantalum, tungsten, depleted uranium, antimony, magnesium and their alloys.**	Funston	General Dynamics Ordnance & Tactical Systems FL Another development of shaped charge warheads. General reference is "typically" to Copper. However depleted uranium offers far higher density and temperature than copper for both modes.

Table B. US Patents with references to replacement of Depleted Uranium (DU), or warhead technologies using unspecified "dense metals"

US Patent Number	Date	Title and extracts from patent specifications	Inventor	Assignee/Organisation & comments
5,656,792	Sept 16, 1996	**Projectile** A bomb in accordance with the disclosure of British Patent No. 1,605,340, for the attacking of concrete targets such as launch pads, possesses a hollow charge for the preboring of the launch pad and an explosive projectile constituting a follower projectile. Through the high energy of the penetrator 14, the latter penetrates through the target.	Rentzsch	Diehl GmbH & co Germany German invention with UK & US patent registration. Describes Durandell type runway breaking weapon. No reference to metals used but high kinetic energy for the following projectile likely to involve high density casing.
5,910,638	Nov 28,1997	**High density tungsten-loaded castable explosive** **Tungsten and other heavy metals, such as depleted uranium (DU), have been used in shaped charges, as the penetrator case or as a liner within the case**. In the case of military warheads, the purpose has been to increase the total weight of the warhead for better penetration performance**. With current environmental concerns**, tungsten has been the preferred heavy metal, since it is essentially inert. However, **structural strength limitations have been experienced with tungsten liners in large penetrator warheads**. At the same time, fabrication of tungsten liners and cases is costly. Further, concentration of heavy metal at the walls of warheads degrades fragmentation performance	Spencer	US Air Force Acknowledges DU use in shaped charge warheads, as penetrator casings or liners (ballast) within casings prior to 1997. This patent acknowledges environmental concerns about DU in 1997. Note technical and cost limitations of Tungsten in large penetrator warheads. Tungsten metal is tougher than Uranium alloys hence not so effective for fragmentation.

6,135,028	October 14, 1998	**Penetrating dual-mode warhead** A penetrating, dual-mode warhead having soft target, surface burst mode and a hard target, penetrating mode is provided. The warhead has a cylindrical outer fragmenting shell which contains an explosive surround. A long-rod penetrator with an explosive payload is located within the outer fragmenting shell. During impact with a soft target, the external shroud and surround explosive is not stripped away. In this sequence, **the penetrator's main charge** is detonated by the fragmentation charge and both charges contribute to the surface blast.	Kuhns	US Navy No indication of metals used in the case or penetrator. The "long rod" penetrator has an explosive core. This may refer to the GBU-24 AUP-116 with explosive fill inside the outer "shroud" (see Patent 6389977, page 5).
5,876,793	March 2, 1999	**Fine powders and method for manufacturing** A bed of tungsten powder in which the particles have an average diameter of about 3 microns may be fluidized in a reactor using a turbulent fluidization flow, and coated with approximately 20 to 30 percent by volume of a mixture of titanium and hafnium. These coated powders are then blended with a transient liquid phase sintering aid, for example, copper, nickel, palladium, and the like, as sintering aids. The resulting admixture may be cold-pressed into a compact at approximately 5000 to 20,000 pounds per square inch applied load. The resulting compact may then be transient liquid phase sintered at a temperature between about 700 and 950 degrees Centigrade, and annealed to form a high density alloy material. The material may be further densified, for example, using high energy rate or upset forging, or through swagging **to form a fully dense penetrator material mimicking the properties of depleted uranium.**	Sherman	Ultramet, CA Indicates the quest to match the properties of DU (high density and pyrophoricity by including Titanium)

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