Blue Danube
The British Nuclear Weapon No 1

Following the end of WW2 the USA formally ceased any cooperation with the UK regarding the development of nuclear weapons (Mc Mahon Act 1946). Prior to this the UK had been heavily involved in the Manhattan project culminating in the development of a Uranium bomb (Little Boy/Hiroshima) and a Plutonium bomb (Fat Man/Nagasaki).

In 1946 the UK government issued a specification for its own design atomic bomb. This was OR 1001 that amongst other things defined the overall dimensions of the large bomb casing which was given the code name 'Blue Danube' (BD) These dimensions also applied to the specification for the new generation of V bombers, Valiant, Vulcan and Victor that were to be ordered by the government to deliver the weapon. Two Short Sperrin prototype aircraft were also built that were capable of carrying the weapon. They were used for BD ballistic test drops over Orford Ness.

The nuclear warhead known as the 'physics package' was to be based on the Fat Man Plutonium implosion bomb dropped on Nagasaki on 9th August 1945.
A project team headed by William Penny who had been a key member of the UK team at the Los Alamos Laboratory was initially established at Fort Halstead in Kent. Penny was a mathematician and physicist who was closely involved with the Fat Man bomb development and witnessed its use over Nagasaki. Penny's development team then moved to their permanent home in Aldermaston. Development of the Blue Danube casing and all aircraft integration work was carried out in great secrecy at RAE Farnborough.

The UK developed a nuclear facility at Windscale in Cumbria that could produce plutonium and other nuclear materials required for the project under the cover of power generation. The actual nuclear bomb was known as the physics package and was officially rather prosaically known as the UK 'No1' nuclear weapon. This fitted tightly inside the cylindrical Blue Danube bomb casing central section.

The Blue Danube Nuclear Weapon Casing finished in Deep Brunswick Green. © Crown copyright

The Blue Danube No 1 Nuclear Weapon Physics Package
The design of the physics package progressed and the first successful live test of the protype design took place in the Monte Bello islands (Trimouille) in Western Australia on 3rd October 1952. The weapon was installed in the hold of HMS Plym and the detonation created a 6m deep 300 m wide crater in the sea bed. (Operation Hurricane)

The Physics Package was a 5 feet (152.4cm) diameter sphere supported by means of two circular aluminium frames that are connected to the outer bomb casing. The sphere

comprises of a complex network of high explosive lenses. When detonated simultaneously the explosives create a circular shockwave as the lenses decompose resulting in a powerful symmetrical compression of the bomb core components.

The Physics Package sphere consists of 32 truncated pentagonal lenses filled with RDX/TNT explosive with the lower conical cavity filled with Baratol (TNT+ Barium Nitrate) explosive. The Baratol was placed immediately below the (duplicated) Fusible Bridge Detonators that were embedded in each lens. The Fusible Bridge Detonators were specialist devices developed in the US for the Fat Man bomb. They used very fine platinum wires that vaporised simultaneously in microseconds when a high voltage pulse of energy was applied. The detonators were 'potted' in a casing about the size of a tennis ball filled with the very powerful explosive PETN (Semtex mix)

Below the lenses, in the centre of the bomb, were 2 aluminium hemispheres that were bolted together to form the spherical 'pusher' The internal contents of the pusher remain classified. We know however there was a cricket ball sized sphere of Plutonium 239 on the end of the Gauntlet known as the 'Pit' There was probably a small amount of Polonium 210 present that functioned as an initiator known as the 'Urchin' This provided an intense source of alpha particles at the moment of prompt criticality. Finally, it is likely that there was a hollow sphere of uranium 238 known as a tamper within the pusher.

The Gauntlet permitted the operational insertion and removal of the fissile core of the bomb. The design of the Gauntlet went through several significant design iterations through the operational life of the weapon. The Physics package itself was subject to continuous design and internal construction development to reflect improvements in component technology etc.

Internal Electrical Design of weapon

Each Bridge Wire Detonator was connected via an equal length coaxial cable to the Firing Unit to ensure their simultaneous detonation.
A bank of high voltage capacitors would be charged by means of an inverter running off the 2X 6V batteries.
A device known as a trigatron was used to instantaneously connect the capacitor bank to the bridge wire detonators when activated. This was a gas filled arc switch device (resembling a valve) that would receive a high voltage activation control signal from the detonator switch network described below.

Arming the weapon

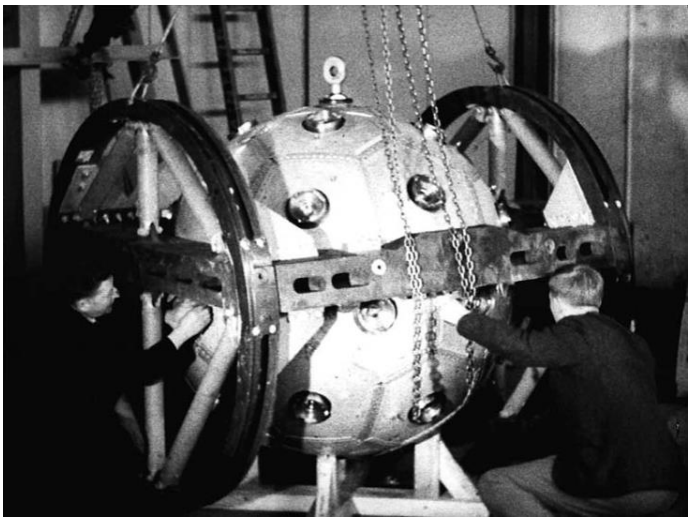
The weapon has 4 switches that are used to detonate the bomb. All of which are duplicated. When the bomb was released from the aircraft the fins were extended using a nitrogen squib physically activated by a connected lanyard. The 12V dc power supply feed to the bomb electronics and high voltage inverter was activated by means of a barometric switch elevating the bomb to the 'partially armed state' as it descended.
The bomb was designed to be an air burst weapon so there are 2 ground proximity radar switch units one set to 2400 feet and one for 1250 feet. When the selected altitude was reached the trigatron was activated by the radar switch.
A clockwork timer switch was provided should radio interference disable the radar switch unit.
An inertial/graze switch was fitted to the nose of the bomb to provide detonation on impact with the ground should all else fail.

Bridge Wire Detonator © Crown copyright

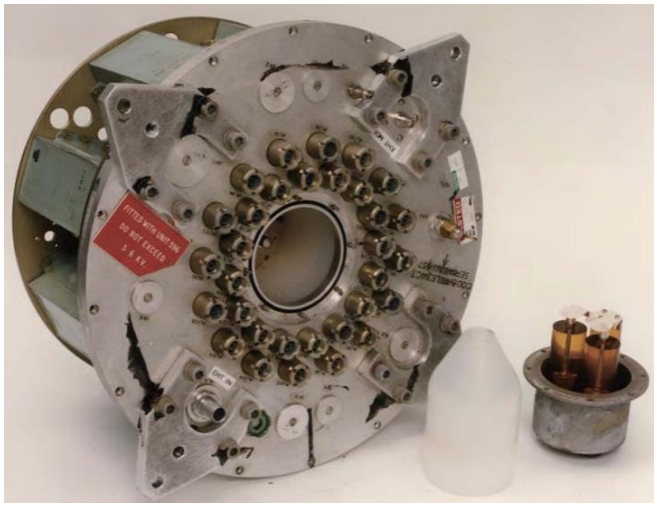
Physics package showing HE lenses and pusher sphere © Pete Sharp

Weapon Operation

When the trigatron is activated, the high voltage energy stored by the capacitors is simultaneously applied to the bridge wire detonators embedded in the HE lenses. The resulting explosive spherical shock wave compresses the plutonium in the pit resulting in a 16kT fission event.



Physics Package © RAE



Firing Unit © Crown copyright

Operational use of the bomb

Safe handling and storage of the weapon was of fundamental importance. The following operational areas are of particular significance.
1. The plutonium ‘pit’ was always securely stored separately from the main physics package.
2. The physics package high voltage capacitor banks were only energised when the weapon had been released from the aircraft.
3. The Blue Danube was secured to the aircraft by means of the same proven system that was used to secure the Tallboy bomb to a Lancaster bomber together with the bomb priming and release control panel.

Loading the Plutonium core (Gauntlet) into the Physics Package

The Vickers Valliant was designed as the primary delivery aircraft for the Blue Danube No1 nuclear weapon. The physics package was subject to continuous development and change as technologies evolved.

A fundamental safety protocol is that the plutonium core is kept separate from the physics package. It is only inserted in the weapon prior to aircraft departure. This has proved to be a significant design challenge resulting in 3 different design iterations as follows:

1. The No 1 Physics Package. The plutonium ‘gauntlet’ was inserted through a hatch in the top of the aircraft into a tube above the bomb. It was then lowered into the bomb secured and armed.
2. The No 1 Mk1 Physics Package. The airframe incorporated an electrical insertion and removal system for the ‘Gauntlet’ This could be inserted and armed in flight and also disarmed and removed in flight. The system required considerable insertion force and the mechanism was heavy and complicated.
3. The No 1 Mk2 Physics Package. This required a redesign of the bomb where instead of being inserted into the top of the casing, the gauntlet was inserted from the ground into a port on the lower port side of the weapon prior to departure. The gauntlet could be armed and disarmed from inside the aircraft.

The plutonium pit was probably gold plated to protect and stabilise the relatively soft material.

Gauntlet showing Pu 239 fissile sphere (the Pit) ©Pete Sharp

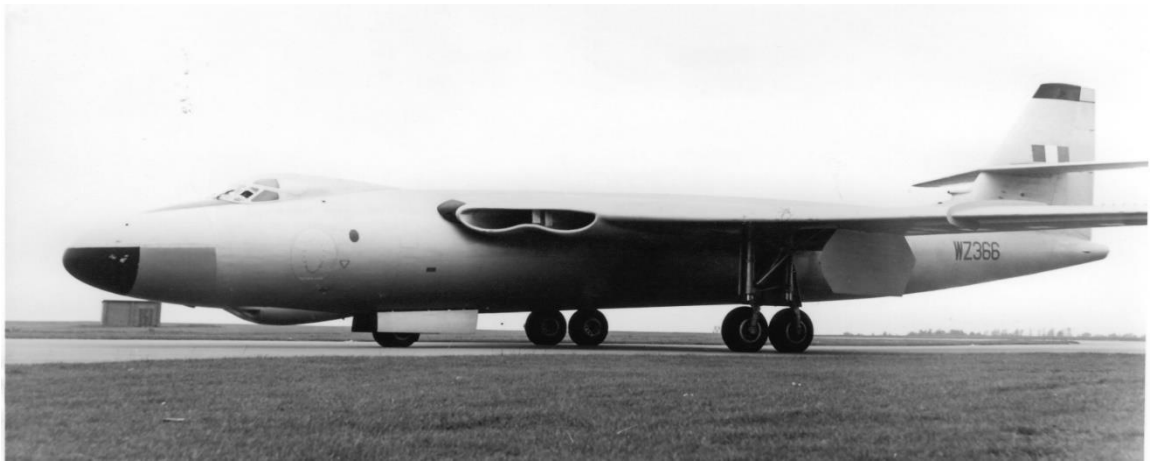
Other components contained within the weapon

The Blue Danube casing required a low and high voltage power supply. Two 6V motorcycle type batteries were incorporated providing a 12v dc supply.
The dual battery power supply was considered a weakness of the bomb design throughout its operational life.
(It is interesting to note that the Red Beard weapon which replaced BD appears to use dual ram air power alternators from observations made on a museum example)
A car type ignition coil circuit was probably used as an inverter to derive a high voltage supply to charge the capacitors rapidly when the bomb was released from the aircraft.
A nitrogen storage cylinder was provided to deploy the tail fins when the bomb was released.
A GRP nose cone was fitted to provide a streamlined housing for the inertial/graze fuses and radar transparency for the radar fuses to operate.

Second prototype Valiant WB 215 releasing an inert ballistic test weapon over Orford Ness

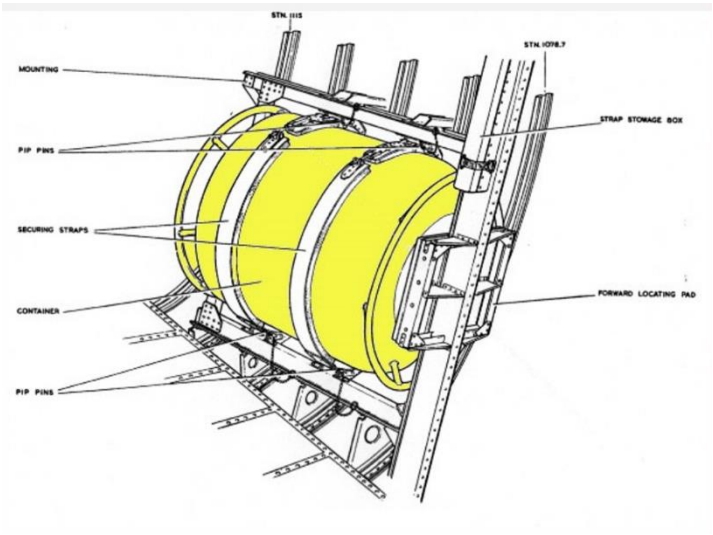
Operational Life of the weapon

The weapon was assembled at the Royal Ordnance factory at Burghfield near Aldermaston and special operational storage facilities were built at RAF Barnham and RAF Faldingworth.



The weapon was live tested at the Maralinga test range in S. Australia on 11th October 1956 being released at 35000 feet from Valiant bomber WZ 366. The bomb was set to detonate at 500 feet with a reduced yield of 3Kt.The aircraft is shown here on its return to RAF Wittering parked by the BCDU (Bomber Command Development Unit)

The weapon without the fissile ‘pit’ was carried by the Valiant in its bomb bay to Australia. The fissile ‘pit’ was transported separately to Australia in a Hastings transport aircraft secured in a specially designed RADHAZ container.



RADHAZ container on ground and shown installed in a Valiant airframe. ©Pete Sharp

©Pete Sharp

Squadron Leader Edwin Flavell, bomb aimer Flt Lt Eric Stacey and crew after returning from Australia. Crew Chief C/Tech Small (right) organised the distribution of a consignment of pineapples to the ground crew at Wittering! (They were unobtainable in the UK in the mid 1950's)

The Maralinga testing sequence was known as Operation Buffalo, the BD drop was the third in the sequence and was known as Operation Kite.

The Maralinga tests also involved a ground test of a reduced yield BD weapon test codename Marcoo.

The other two tests (One tree & Breakaway) involved versions of the Red Beard weapon that eventually replaced BD.

The weapon was finally withdrawn from service in 1963 being replaced by the more compact Red Beard weapon whose construction details remain classified.

This British nuclear weapon kept the UK inside the' international nuclear club' during the 1950's and as relations with the USA improved the UK was then able to resume working jointly with the USA on subsequent weapon developments.

Acknowledgements

1. First Waltz. Development of the Blue Danube. Jonathan Aylen University of Manchester
2. Pete Sharp (RAF Rtd)
3. Crown Copyright
4. RAE
5. Google search