Experimenting with High Explosive Fuel Explosions for Movies and Television

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ABSTRACT

A number of 'brute force' techniques used within the special effects industry utilise high explosives to create the classic 'Hollywood' style fuel explosion seen in many a movie and television programme. Limited experiments have shown that application of techniques similar to those used in shaped charge anti-tank weapons (the Munroe effect) can produce higher and larger fuel explosion effects, while using less fuel and explosive material, thereby creating a more controlled effect.

Keywords: high explosive, fuel explosion, special effects, directional shaped charge, Munroe effect, compression tube

Introduction

As readers of this Journal probably know, the fiery explosions seen in movies and on television are unrealistic. The special effects (SFX) industry achieves these effects by using large amounts of fuel—petrol (gasoline), diesel, kerosene, alcohol or a mixture of these—that are thrown and spread by a suitable bursting or lift charge to create the classic 'Hollywood' explosion.

In the UK, high explosives (HE), generally in the form of detonating cords, are the preferred bursting or lifting charge, however large maroons (salutes) are also used. Whichever bursting or lift charge is used, a secondary ignition charge (usually Black Powder or a similar pyrotechnic heat or flame source) is required to ensure that the vaporised fuel is safely and reliably ignited.

These techniques produce a very satisfying 'Hollywood' type fireball explosion. They simply use the 'brute force' effect of the explosive material to burst a fuel container and/or throw the fuel into the air, forming a cloud of fuel vapour ready for ignition by the secondary ignition charge.

As with any other action, when an explosive charge is fired to burst or lift the fuel, there is an equal and opposite reaction, which can do considerable damage to the local surroundings. The SFX industry tends to use kicker plates (Figure 1), mortar pots—for more directional bursts (Figure 2) or similar items to "give the explosive something to push against" thus protecting the immediate surrounding area.

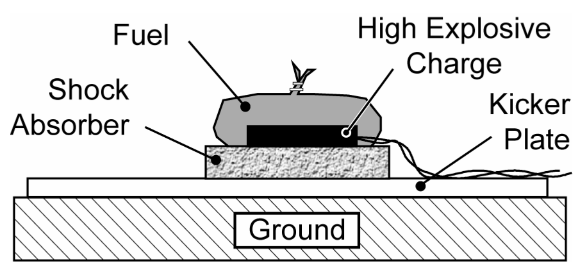

Figure 1. Example setup for a non-directional fuel explosion.

A sacrificial shock absorber (such as firm foam) is needed between the HE charge and the kicker plate or mortar pot to prevent the direct transfer of shock waves into the metal of the kicker plate or mortar pot. Direct contact between the metal and HE during detonation can cause metal fragments or scabs to break off and fly considerable distances.

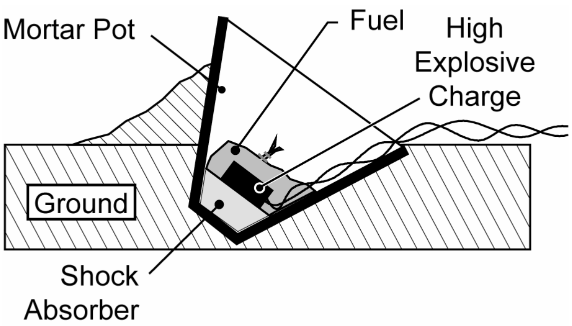

Figure 2. Example of setup for a directional fuel explosion.

However, HE has properties other than shear 'brute force' that may be harnessed and used with finesse to produce higher, larger and more controlled fuel effects while using lower amounts of fuel, thereby reducing the risk of secondary fires in the surrounding area.

Requirement

The requirement, and hence these experiments, originally came about through an enquiry from a conceptual artist who wanted to film a 100 foot (33 m) high column of fire and project the footage onto the wall of a gallery as part of a piece of 'installation art'.

After an initial meeting it was established that the column of fire needed to be 50 feet high rather than the stated 100 feet, as 50 feet (16 m) would be the approximate height of the frame seen by the camera. A number of pyrotechnic-based techniques were tried, but they did not produce the volume of instantaneous rich fire required in the column effect. Eventually it was decided to apply shaped charge techniques in an attempt to solve the problem.

Experiments

An ideal experimental assembly was designed (Figure 3) that consisted of a hollow cylinder of explosive that could be detonated at one end, simultaneously around its entire circumference, with the centre of the cylinder being filled with fuel. The theory was that the contents of the cylinder would be compressed toward the central axis. Since the charge initiates from one end, the compressed fuel is forced out through the open (yet to be detonated) end of the cylinder, thereby propelling the fuel high into the air. However, due to the complexity of achieving simultaneous initiation with the limited resources available, a more practical experimental assembly had to be designed (Figure 4).

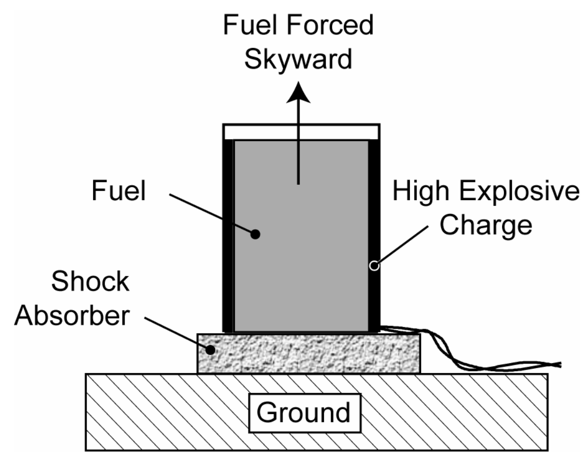

Figure 3. Ideal experimental assembly.

The assembly was based on a large diameter, thin walled cardboard tube, which was of a wound laminated construction, having a diameter of 500 mm, a wall thickness of 4 mm and a height of 600 mm.

The top three quarters of the cardboard tube would be wound with PETN-filled detonating cord (nominally 10 grams [150 grains] per metre), in a helix pattern around the tube with a pitch of approximately 30 mm; this would consume 18 metres of detonating cord.

Four equal lengths of detonating cord were to be attached (using duct tape) at equal spacing around the circumference and vertically down the outside of the tube. These lengths would be bound together where the detonator was to be attached, so that the length of detonating cord between the detonator and the cardboard tube was exactly the same for all four pieces. This was designed to produce four simultaneous and equally spaced points of initiation around the diameter of the cardboard tube.

The bottom quarter of the tube would be filled with approximately 12 litres of water in-

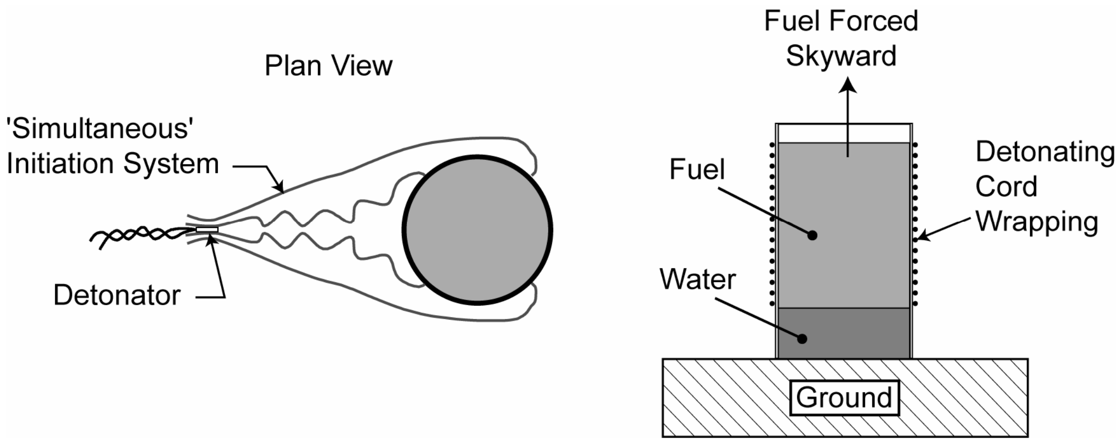

Figure 4. Practical experimental assembly.

side a polythene bag. The water was intended to elevate the fuel and explosives, thereby reducing the blast damage to the ground and surrounding area. In addition, the water would be rapidly dispersed over the local area to reduce the risk of secondary fires.

The top three-quarters of the tube was to be filled with fuel: a mixture of 12 litres of petrol (gasoline) and 24 litres of diesel oil. This mixture was chosen to give the required rich orange-yellow flame colour and good dark smoke to complete the effect, once the fire had died away.

To test the system cheaply a number of scaled-down versions were manufactured. The scaled-down versions were fired and compared with equivalently sized versions of the 'brute force' techniques detailed earlier (Figures 1 and 2). These versions contained only 1 litre of fuel; however the scaling of the explosive content left only a single turn of detonating cord wrapped around the small scale cardboard tubes. However, this was felt to be sufficient to act as a guide as to whether the full-scale version would achieve the required effect.

Scaled-Down Results

The scaled-down 'compression tube' firings produced higher, tighter and more impressive looking fuel explosions than the same sized 'brute force' firings. The 'compression tube' firings also produced less damage and lower incidents of secondary fires. The fireballs from 1 litre tests are documented in the series of three photos in Figure 5. These results encouraged us and indicated that the full-scale version should produce the required high, dense and rich column of fire that had been requested.

Full-Scale Experimental Firing

Following the small scale firings a single full-scale assembly was built and tested: the cardboard tube was positioned and filled as shown in Figure 6. The four equal lengths of detonating cord making up the 'simultaneous' initiation system were carefully laid out, so that they were well separated and not kinked. The secondary ignition charge was attached to a steel post approximately 1 metre away from the full sized 'compression tube' and the detonator was attached to the junction between the four lengths of detonating cord.

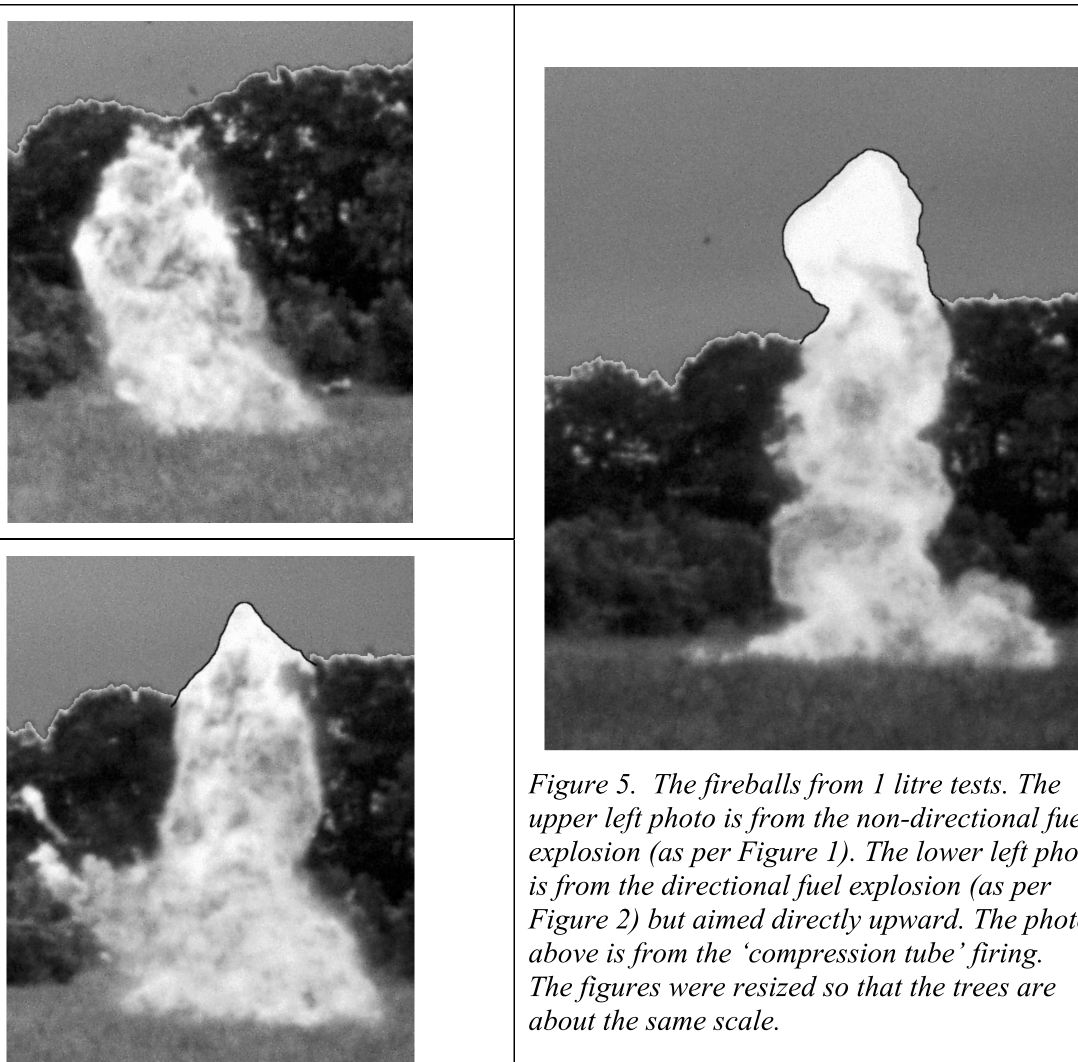

Figure 5. The fireballs from 1 litre tests. The upper left photo is from the non-directional fuel explosion (as per Figure 1). The lower left photo is from the directional fuel explosion (as per Figure 2) but aimed directly upward. The photo above is from the 'compression tube' firing. The figures were resized so that the trees are about the same scale.

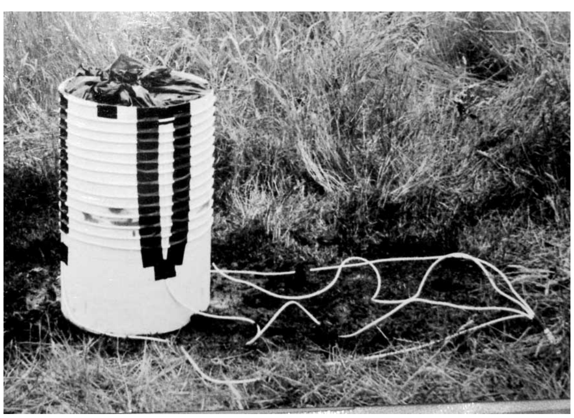

Figure 6. The first full scale experimental assembly.

The full-scale firing produced a dense and rich column of fire that was approximately 50% higher than the stated requirement of 50 feet and can be seen in Figure 7. Two, very successful, full scale firings were carried out in front of a child's 'A' frame swing and were filmed by the conceptual artist. One of these is now titled "Automation" and has been shown at an art exhibition in Barcelona. A shortened clip of "Automation" can be seen on the web at:

http://www.liveactionfx.freeserve.co.uk/SFX%20swing.htm

[NOTE: This leads you to a low resolution version of the photos in this picture and a link to where you can download a 2 MB movie clip.]

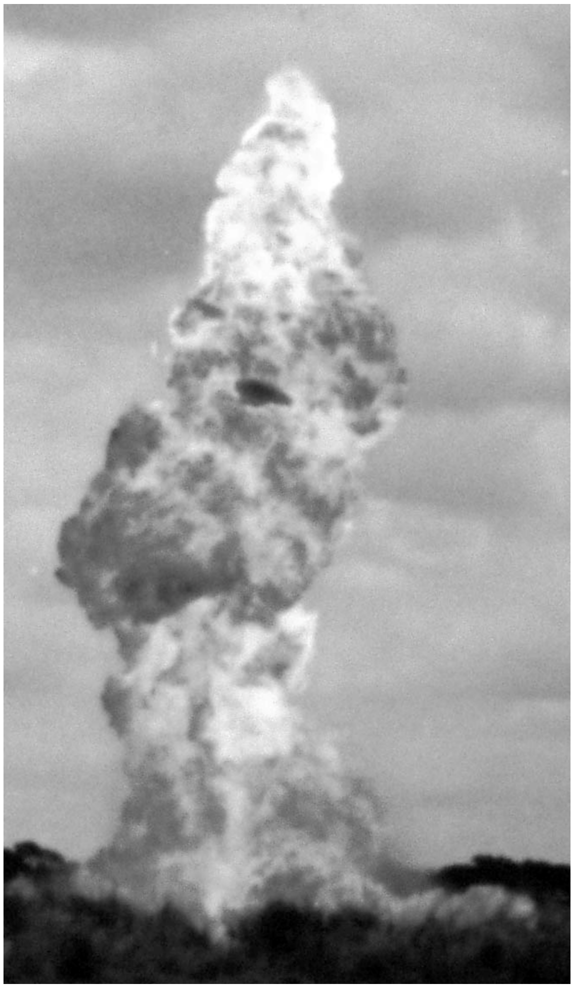

Figure 7. The full-scale firing.