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NON-LETHAL SYSTEMS R&D  
NIJ COOPERATIVE AGREEMENT

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FINAL REPORT

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NON-LETHAL WEAPON SYSTEM  
RESEARCH AND DEVELOPMENT

Pepper Spray Launcher/Dispenser

1 Summary

An improved less-than-lethal (LTL) projectile has been developed capable of dispersing the incapacitating agent oleoresin capsicum (OC) launched from a standoff position for use in hostage, barricade and tactical assault situations.

2 Relevance to Law Enforcement

There is widespread recognition in the law enforcement community of the need to offer a greater range of improved weaponry to subdue criminals without causing injury to either the criminal or innocent bystanders. The desire to provide police officers with additional tools to verbal persuasion, a baton, or a firearm has focused attention on the application of new technologies to the development of LTL weapon systems.

Chemical agents have found widespread use in civil law enforcement organizations. Peripherally acting chemicals, particularly the tear gas agents CN and CS, have been used extensively. CN and CS are both classed as lacrimatory chemical agents which, in addition to lachrimation, cause rhinorrhea and a severe irritating and burning sensation to the eyes, nose, throat, and exposed skin.

Despite their widespread adoption, a number of concerns and limitations have been recognized in the use of tear gases. CN has been known to cause fatalities when used in confined spaces, and neither agent is effective on animals or on highly motivated or emotionally disturbed individuals or those on drugs or alcohol. Decontamination of areas affected by CN and CS is frequently a lengthy and involved procedure, severely restricting the use of tear gases in public buildings.

In recent years a new type of spray has been developed that uses various formulations based on the essence of cayenne and chili peppers, the active ingredient of which is the oily resin of pepper, OC. OC, unlike CN and CS, is derived from a natural product and is widely used as a foodstuff and in pharmaceutical products. It acts as an inflammatory agent producing involuntary closing of the eyes and profuse lachrimation. Other physiological effects of OC are temporary paralysis of the larynx and gasping for breath due to inflammation of the

mucous membranes and the upper respiratory tract. These effects of OC can combine to produce a complete loss of upper body motor control when used in sufficient concentrations, resulting in complete immobilization.

OC sprays, or pepper sprays as they are commonly called, have now largely replaced CS and CN for use in apprehending individuals in one-on-one situations. Unfortunately however, despite all their advantages over the tear gases, pepper sprays have not yet been widely used from a standoff position for crowd control or to counter hostage/barricade situations.

Commercially available long range (50 meters and beyond) tear gas guns typically fire 37 mm or 40 mm gas shells, each weighing about 7 oz (200 grams), at muzzle velocities of about 100 to 200 feet/sec. The projectile drop corresponding to these muzzle velocities is considerable even at short ranges. Aiming sights are therefore used to determine the correct angle to elevate the barrel to compensate for projectile drop. Because of their lob-like flight characteristics, these weapons rely on precise range estimation on the part of the operator to achieve any degree of success in hitting the intended target. These crude sighting devices are adequate for riot control purposes where the projectiles are not designed nor intended for direct use against crowds because of the risk of fatalities, but are not particularly accurate for use in barricade situations. Conversely, the more recent development and employment of liquid-filled shotgun shells fired from relatively inexpensive 12-gauge shotguns suffer much less from projectile drop but are associated with unacceptably low payloads (typically 0.1 oz) for the present application.

Striking confirmation of the need for this technology in law enforcement was provided by the NIJ survey conducted following the LTL Technology Demonstrations held at the Montgomery County Police Department Training Center in Rockville, Maryland, on March 13, 1995. Of the 28 officers who witnessed the demonstration of the prototype pepper spray projectile developed in this study, 19 categorized the device as "very useful" and 6 as "somewhat useful". Several officers pointed to the importance of pepper spray technology within the framework of LTL weapon technology and its advantages over the tear gas agents CS and CN. The application of this device to barricaded subjects in juvenile facilities and prisons was also highlighted by some of those surveyed.

### **3 Statement of Work**

The modified Statement of Work identified the following characteristics for the pepper spray launcher/disperser:

- Capable of being carried and operated by a single person.
- Able to deliver the projectile at up to 100 feet (essential) or 150 feet (desirable) with sufficient accuracy to repeatedly hit a 3 feet x 2 feet target, using only a simple sighting system, by an operator requiring only a minimum amount of training.

- Able to deliver the projectile through a plate glass window or household window glass with a screen or blind, yet be non-lethal at the minimum operational range (50 feet) in the absence of any obstacle.
- Capable of delivering a fine atomized spray of liquid sufficient to fill a room at least 10 feet by 10 feet by 9 feet within one second of penetrating the above glass targets, or on striking an internal wall or ceiling if entry to the room can be achieved through an open door or window.

#### 4 Project's Findings

4.1 An extensive literature study was conducted on LTL projectiles and launchers. The study turned up over three hundred references, of which more than 20 reports and 40 patents were studied in detail for their relevance to the current project. Most of these reports originated from Army funding of LTL work conducted in response to the widespread mob violence of the sixties and early seventies.

A recent Army Research Laboratory publication ("Less-Than-Lethal Weapons Development for Law Enforcement" by David H Lyon ARL-TR-51 Army Research Laboratory, Aberdeen, February 1993) gives an excellent overview of the Army work in this area, including the work performed in support of the National Institute of Justice program arising as an outgrowth of the First (1972) and Second (1986) National Conferences on LTL Weapons.

One important area where the literature study did little to provide much information is on the mechanism of barrier defeat for targets (glass, doors, walls) relevant to the current study. In particular, very little information is available in the published literature on the penetration of various shaped projectiles into the targets of interest in this study. This data is needed to determine the trade-offs between standoff, velocity, projectile size and shape, penetration, and residual energy.

4.2 It was determined that the target response involved in penetrating barriers such as glass or walls with impact velocities typically less than 1,500 feet/sec is largely based on the strength of the material, and the impact response is primarily elastic. This work illustrated the need for penetration data for several basic projectile shapes against the targets of interest in this study (glass, doors, walls).

4.3 Calculations were made of the projectile diameter necessary to hold sufficient OC material to incapacitate the occupants of a typical 900 cubic feet room. These calculations pointed to a projectile diameter of at least 37 mm in order to hold a minimum payload of 1 oz of liquid spray. (Later experimental results pointed to the need for high pressurization of the contents and hence rapid dissemination rather than quantity of contents as the key to effective incapacitation.)

4.4 Trajectory and recoil analysis programs, developed under the privately funded Delta Weapon System program (both in-house and using Delta's contractor Beacon Technology Inc.), were applied to the pepper spray launcher/dispenser program. Computations of trajectory and recoil for a wide range of projectile weights and shapes, and muzzle velocities were determined. Confirmation of flight stability and trajectory calculations was obtained using a 34 mm test barrel fitted with parallel rifling and capable of being spun at various speeds. A range of solid aluminum cylindrical projectiles weighing 7 oz was successfully fired in stable and essentially flat trajectories from this test fixture, with muzzle velocities ranging from 400 to 900 feet/sec. Both recoil impulse and recoil energy at these velocities are considerable but various techniques are available to manage high levels of recoil by reducing the felt recoil imparted to the firer.

At this stage in the program a decision was made not to develop a new dedicated launcher for the pepper spray projectile because the perceived advantages did not justify the expense of law enforcement officers being required to purchase yet another weapon system. Efforts instead were diverted to ensuring that the pepper spray projectile could be fired from existing 37/38 mm law enforcement riot control guns, with the technology being adaptable to existing military 40 mm grenade launcher systems in the event that these systems eventually become available to law enforcement officers. This decision effectively acknowledged that current technology was unable to ensure that the pepper spray projectile would be non-lethal if the subjects are too close to the launcher and, at the same time, ensure that the accuracy requirements could be met at ranges up to 150 feet. A projectile launcher with impact velocity control, such as is being currently developed with NIJ funding by the Lawrence Livermore Laboratory, offers the promise of one day being able to overcome this current technological deficiency.

4.5 A standard 37 mm riot control launcher was used to generate penetration data using a wide range of projectile shapes impacting various targets at different velocities. Measurements were made of muzzle velocity, accuracy at various ranges, penetration data and residual energy against the glass and screen targets in this study. Targets were constructed according to NIJ Standard 0111.00 (Barrier Penetrating Tear Gas Munitions). The results indicated that a hemispherical ogive offered the best compromise between flight stability and the desire to retain non-lethality at the velocities needed to minimize projectile drop to permit a simple sighting system to be employed.

4.6 A theoretical and experimental assessment was carried out of the relative merits of stabilizing the projectile in flight by means of spin using a rifled barrel and by means of fins using a smooth bore barrel. Fin stabilization was found to work best for projectiles with relatively high length to diameter ratios such as those used in the present study.

4.7 Various fin stabilized plastic projectiles were constructed to hold off-the-shelf pressurized pepper spray canisters. Two designs were considered, manufactured and tested. Both involved a three part projectile consisting of a machined plastic hollow body with rear fins, a pepper aerosol spray canister from which the spray nozzle had been removed and replaced by

a multi-channel plastic collar, and a pressure sensitive plastic nose cap which activated the device on hitting the target. In one design, the aerosol can was placed inside the plastic body so as to eject the atomized spray from the front of the projectile on impact and in the other design from the rear of the projectile on impact. A test rig was constructed to simulate target impact and to characterize each device. The rig consisted of an aluminum weight allowed to drop onto each device from a calibrated height. The results of these static tests, together with live firing trials against a variety of targets, showed that rear ejection of the atomized spray was more reproducible and effective than nose ejection.

4.8 Refinement of the external design of the projectile was carried out using the PRODAS suite of computer programs for projectile modeling and aerodynamic, stability and trajectory analysis. The program computes the total projectile weight and moments of inertia, analyzes the aerodynamics and stability of the projectile in flight and predicts its dispersion at various ranges. The program was used to refine the fin design (number of fins and their shape and location) to improve flight stability and ensure that the projectile always hit the target nose first to activate the aerosol canister. Flight trials of the improved design demonstrated its superior flight characteristics and dispersion against the NIJ standard barrier for testing tear gas agents.

4.9 Various modifications to the aerosol release port design were made in an attempt to improve the efficiency and speed of discharge of the aerosol canister contents within the barrier structure. Some improvements to the original design were achieved but it did not always prove possible to discharge the entire contents of the can reproducibly within one second of impact as required by the Statement of Work. Further improvements to the valve design would undoubtedly improve the discharge rate, but calculations showed that the greatest improvement would come from increasing the internal pressurization of the can. Such improvements would necessitate designing a stronger can or designing the projectile body to act as the pressure vessel.

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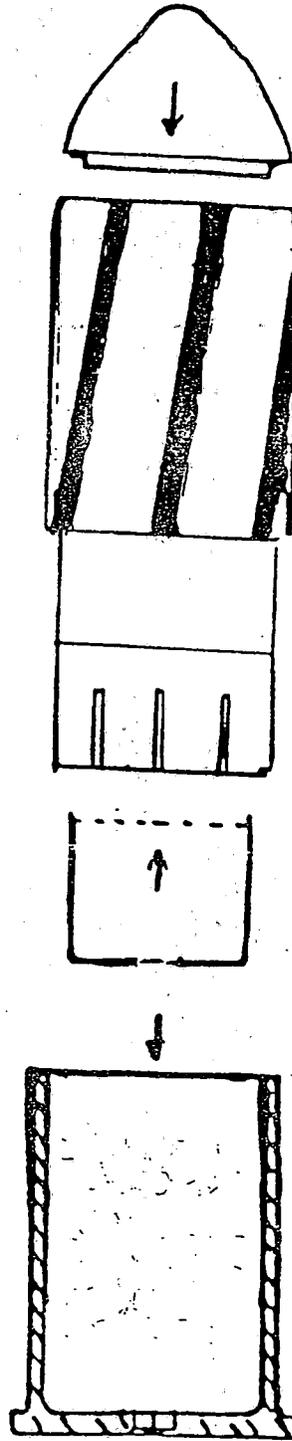
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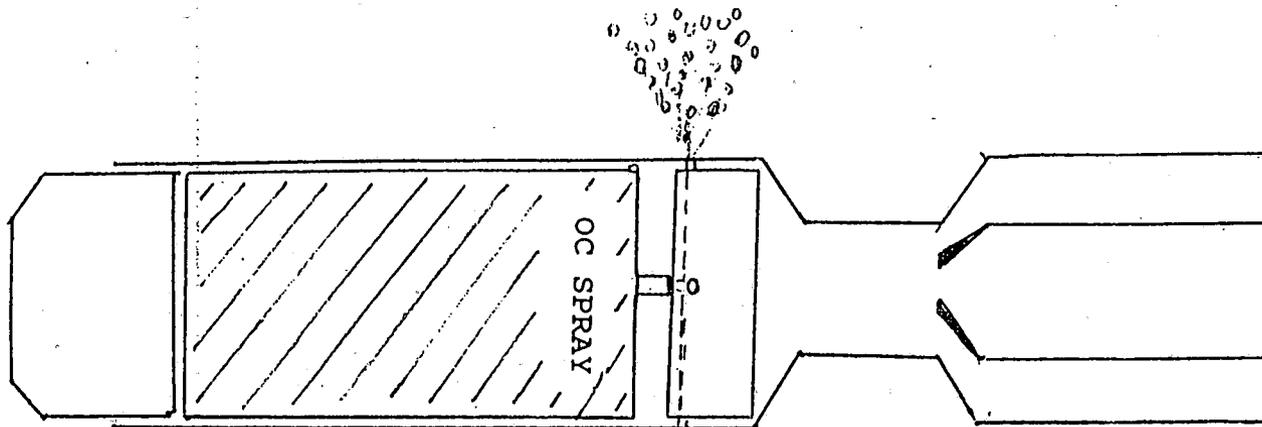
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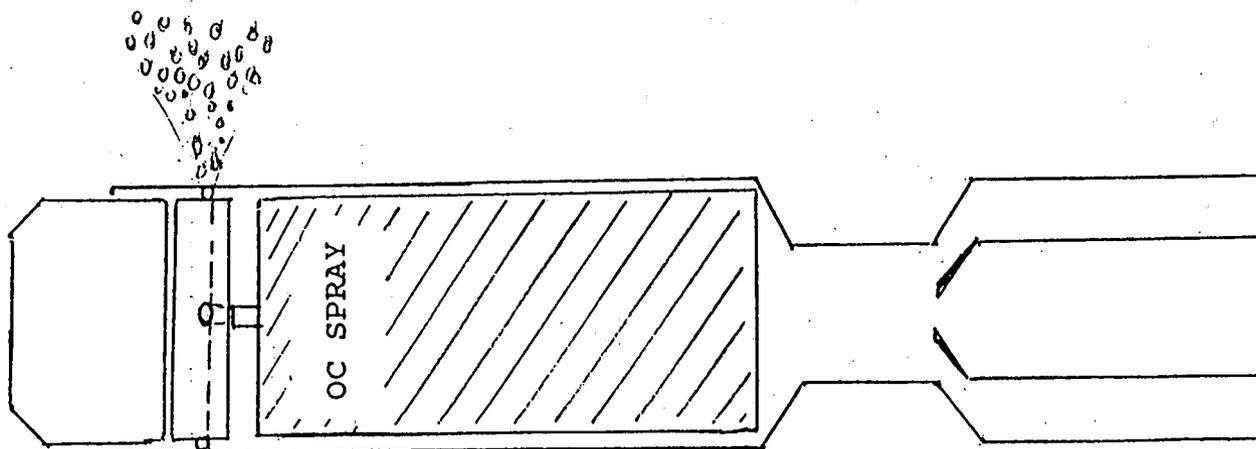
WINCHESTER 209 PRIMER



PHASE II TEST PROJECTILES



**BASE EJECTION PROJECTILE**



**NOSE EJECTION PROJECTILE**