Sticky Shocker*

Edward Vasel**, John Bryars, Peter Coakley, Charles Mallon,
Jeff Millard, Gregory Niederhaus and Scott Nunan
Jaycor, San Diego

INTRODUCTION

A non-lethal method is being developed to extend the range for effectively electrically stunning a person. Present technology, consisting of stun guns and tasers, is limited to distances of less than 4 meters. The Sticky Shocker, shown in Figure 1, is a low-impact wireless projectile fired from compressed gas or powder launchers and is accurate to a range of greater than 10 meters, sticking to the target with a glue-like substance or with short clothing attachment barbs. The projectile incorporates a battery pack and associated electronics that impart a short burst of high-voltage pulses capable of penetrating several layers of clothing. Pulse characteristics into a human body are approximately 10 amps peak current, 1.0 microsecond pulsewidth, 0.2 joule energy, at a repetition rate of 12-15 pulses per second. These pulse characteristics are electrically safe, being similar to well-established non-lethal electrical shock devices, and will disable individuals or cause extreme discomfort. The projec‥le design is compatible with conventional 37/40 mm less-lethal weapon launchers. Applicable missions include any stand-off encounter where an individual needs to be temporarily incapacitated and taken into custody without exposing law enforcement officers or military personnel to unnecessary risk. The presentation will discuss the projectile configuration, shock characteristics, compatible launchers, and prototype field demonstration results.

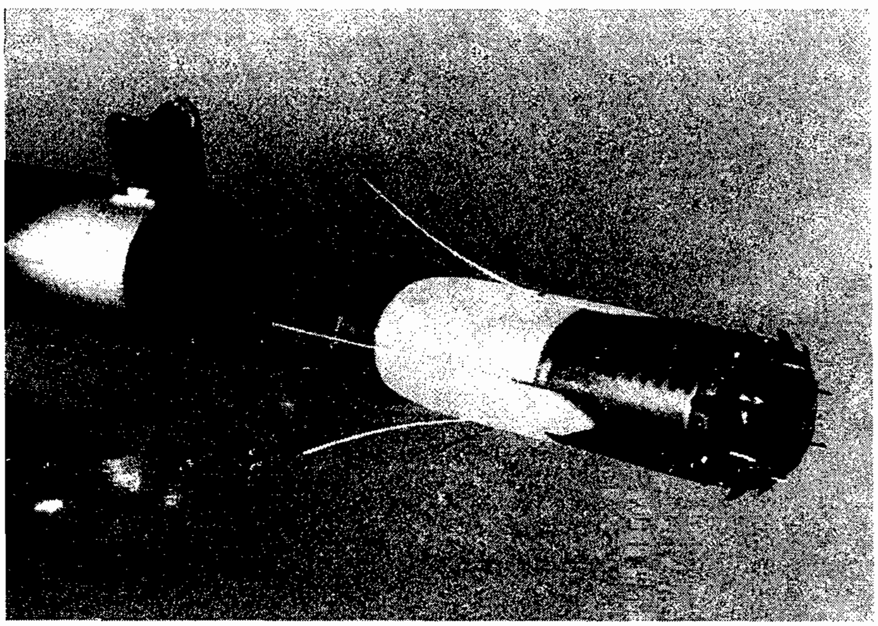

Figure 1. Sticky Shocker is a non-lethal electrical stun projectile.

* "Sponsored by the DoD/DOJ Joint Program Steering Group, at DARPA, and funded as a result of BAA 95/28. The views and conclusions expressed in this document are those of the authors and should not be interpreted as representing official policies, either expressed or implied, of the Defense Advanced Research Projects Agency or of the U.S. Government."

** For additional information contact Edward Vasel at (619) 453-6580 ext. 216 or evasel@jaycor.com

J203-98-0007/2990

Approved for Public Release

BACKGROUND

There is a renewed interest in developing less-than-lethal (LTL), less-lethal, or non-lethal technologies. The US and UN military forces are being called upon to police in foreign territories where there is no clear-cut distinction between friend or foe and where foes are often intermingled with friends or civilians. At the same time, law enforcement personnel across the US are faced with the ever increasing challenge of subduing hostile individuals in the face of a litigation-prone society.

Initial interest in LTL technologies came about in the late 1960s and early 1970s, mainly due to civil disturbances, anti-Vietnam war demonstrations and associated student unrest. Two important tools or LTL weapons were developed in this period—the taser (which fires two wire-tethered barbs) and the less lethal kinetic munitions (such as rubber bullets, beanbags, and wooden batons). These are in wide use today.

Law enforcement and military personnel have limited LTL options when opposed by a potential hostile. Recently, pepper spray was added to the arsenal of tasers and kinetic bullets, but like tasers, pepper spray is effective only at close range. Neither pepper spray nor tasers are useful in halting a fleeing suspect.

The idea of the Sticky Shocker came about in response to the challenge to provide an LTL weapon that filled the gap between kinetic rounds and devices that are useful only in close contact situations. The Sticky Shocker concept, as shown above in Figure 1, puts stun gun technology on a wireless self-contained projectile, allowing greater and therefore safer standoff distances. It has been designed to be compatible with current law enforcement and military launch platforms.

DESCRIPTION OF THE PROJECTILE

The Sticky Shocker is a free flying projectile that attaches itself to the target. Figure 2 shows a prototype projectile with three different tip options: barbed, adhesive or combination tip. The projectiles measure 10 cm (4.0 in.) long by 40/37 mm in diameter (~1.5 in.). The Prototype projectiles weigh 135 g (4.5 oz., a little lighter than a baseball). High-voltage electrodes are positioned at the front and rear. The projectiles are ballistically stable, with a center of mass along the cylinder axis and forward weighted. The unit is powered with 6 AAAA batteries.

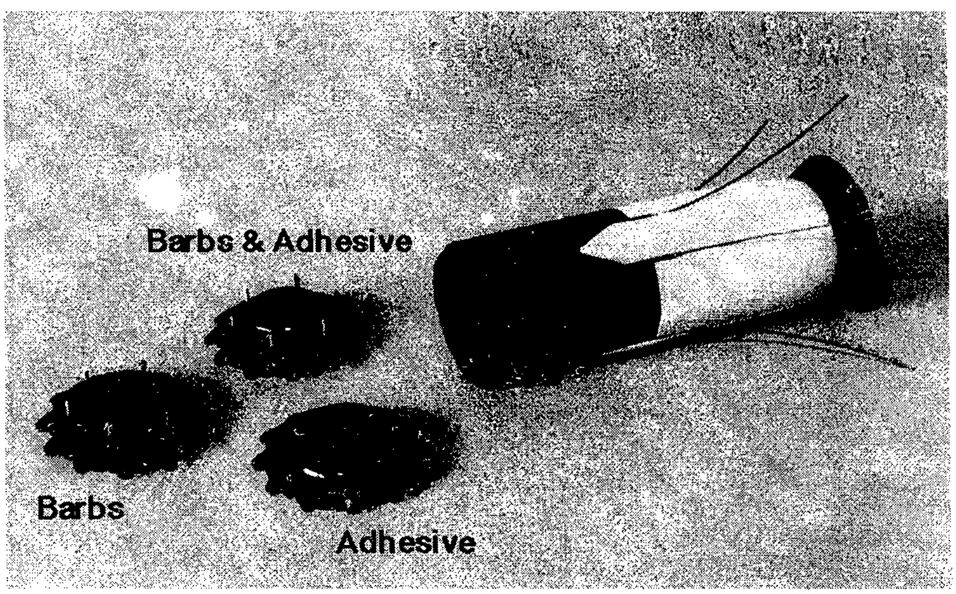

Figure 2. Photograph of Prototype Sticky Shocker projectile with three optional attachment tips.

Figure 3 shows a block diagram for the Sticky Shocker circuit. It features a battery, an arming switch (that initiates pulsing on launch), a timing circuit for auto shut off (and safe handling following use); a charging circuit; and output stage (comprising of transformers, capacitors, transistors, a spark gap, and electrodes).

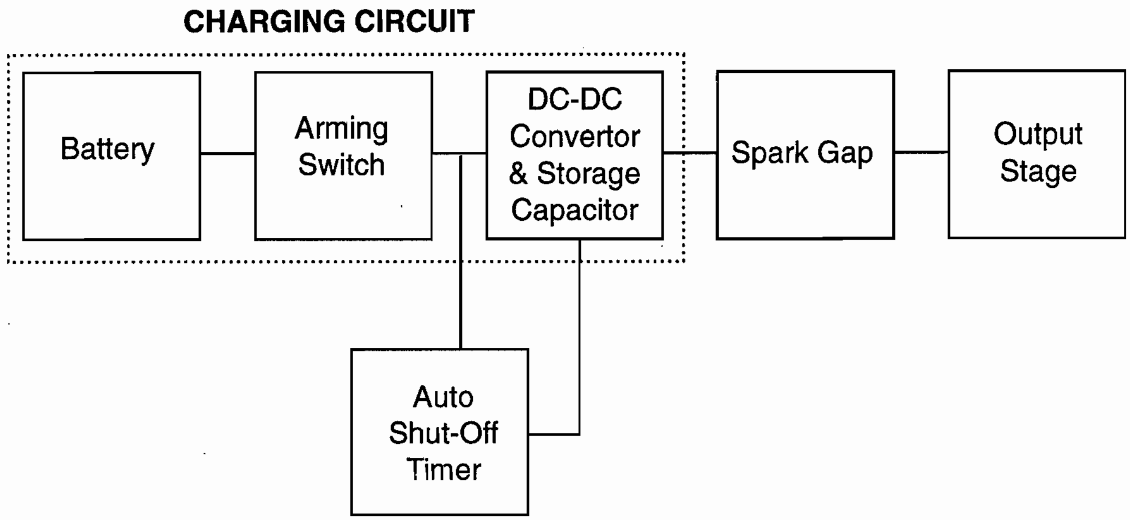

Figure 3. Block diagram of Sticky Shocker electronics.

ELECTRICAL PULSE AND SHOCK SAFETY

There are a variety of commercial pulse-wave devices on the market that claim pulse voltages ranging from 50 kV to over 200 kV. They possess a range of pulse currents, pulse widths, and pulse repetition rates. Claims of extremely high-voltage pulses appear to be marketing hype. While theoretical open-circuit voltages might be 120 kV or greater, in practice a safety air gap to protect against damaging internal breakdown, limits open-circuit voltage to about 30 to 50 kV. An advantage to higher voltages is the ability to penetrate clothing.

The impedance or resistance of the human body changes with the applied frequency. A person has one impedance for a dc current, determined by the conductivity of their sweat glands and pores, and a much different impedance at much higher frequency current pulses (dominated by the person's salt concentration). The human body has an effective impedance near 1 kΩ at the frequency (Hz) of interest for the pulse waveform stun devices (stun guns and tasers). This impedance limits the current. A device voltage divided by the impedance yields the current that can be delivered. Peak currents from 3 to 20 A are possible, and most devices produce peak currents of 4 to 10 A into 1 kΩ loads.

Figure 4 compares Sticky Shocker output to six commercial stun guns. The Sticky Shocker pulse characteristics are similar to high-end commercial units, with a peak current about 10 A and a damped sinusoid waveform with an effective pulse width of about 1.0 μs. With the high repetition rate of 15 Hz, the root mean square (rms) current for the prototype units was about 54 mA. Thus, target incapacitation response should be similar to the high-end stun guns.

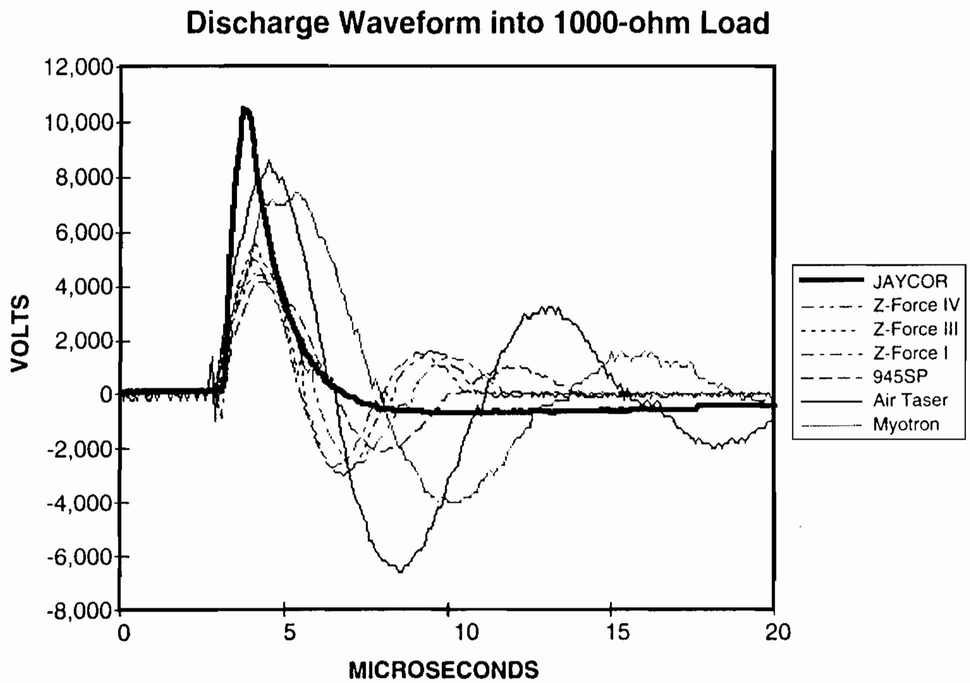

Figure 4. Pulse waveform for Sticky Shocker and other pulse waveform stun devices.

Underwriters Laboratory (UL)[4] and the International Electrotechnical Commission (IEC)[5] have published electrical safety standards for rms current levels for periodic pulse trains—and are directly applicable to pulse wave stun devices like the Sticky Shocker. The standards are based on the rms current, defined as the square root of the average of the square of current. For a series of discrete pulses of arbitrary or complex pulse shapes this is most easily calculated from the measured energy per pulse into a load:

$$\left[I_{rms} = \sqrt{E(J) * rep\ rate\ (Hz) / R\ (\Omega)}\right].$$

Figure 5 shows measured rms current levels for a number of commercial stun guns. The UL limits for ventricular fibrillation have a built-in safety margin of 2x to 5x, based on a 2-year-old child, while the IEC thresholds relate to the probability of introducing fibrillation in 50% of the population. Typical stun guns have a safety margin of at least 100x. Basically, the short pulse duration of the stun guns has very little effect on heart functioning because the heart has a much longer msec pulse.

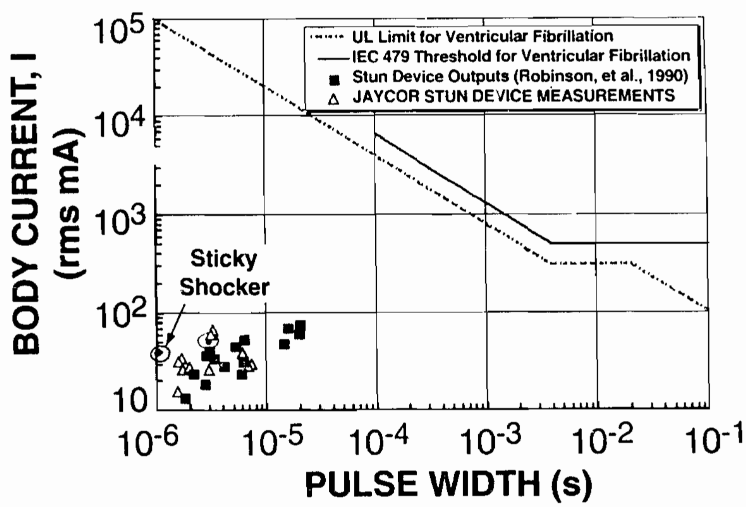

Figure 5. UL and EIC repetitive pulse safety level and rms pulse level for Sticky Shocker and other pulse waveform stun devices.

ATTACHMENT AND IMPACT

In order to incapacitate a target, the Sticky Shocker must attach itself to the skin or clothing of the target individual. Several attachment design concepts were attempted before settling on simple passive designs. One of the promising design concepts involves a tenacious non-toxic glue material, likened to the sticky foam material that Sandia has developed,[6] and another involves a clothing barb attachment scheme. The advantages of these two concepts are that they promise to be cheap and reliable.

Flight tests with the two basic schemes showed excellent attachment at 30 feet to various cloth, leather and nylon materials. Figure 6 shows typical projectile attachments to a cotton T-shirt using barbs (on the left) and an adhesive tip (on the right). The projectile hangs vertical to the target. This configuration allows good contact with the front electrode and rear whisker electrodes. This attachment method allows for maximum spacing of electrodes resulting in a more effective shock over a larger target area.

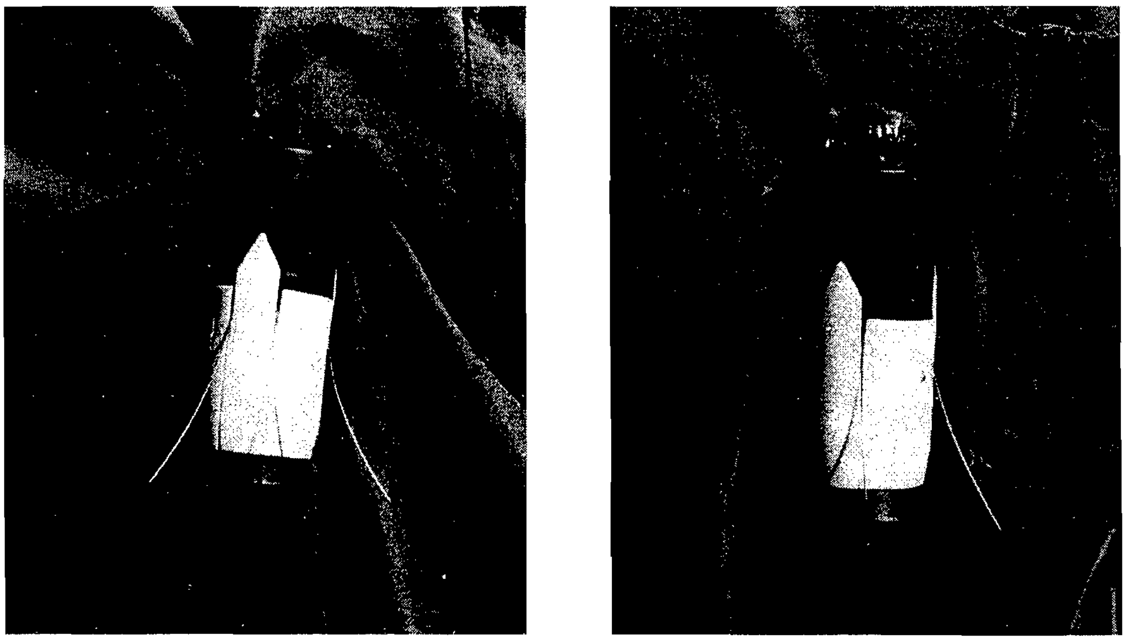

Figure 6. Barbed and adhesive attachments.

To compare the blunt force of the Sticky Shocker projectile to other less-lethal weapons in use the impact force and impulse of a number of weapons were measured using a hydraulic load cell. A hydraulic load cell is a liquid-filled chamber with a lightweight piston, with a known area, that compresses the liquid producing a pressure pulse which is measured with a pressure transducer.

Figure 7 summarizes impact data for the Sticky Shocker compared with other less-lethal impact devices. Both impact force and impulse data are shown. The data are normalized to a 37-mm K01 rubber bullet that is in common use in the law enforcement community. The Sticky Shocker impact was only about 70% of the K01 round, was slightly larger than the MK Flex Baton (shotgun bean bag),[7] and was mid-range compared to a variety of police baton types. For impact trauma, the Sticky Shocker is as safe as other less-lethal weapons in present use.

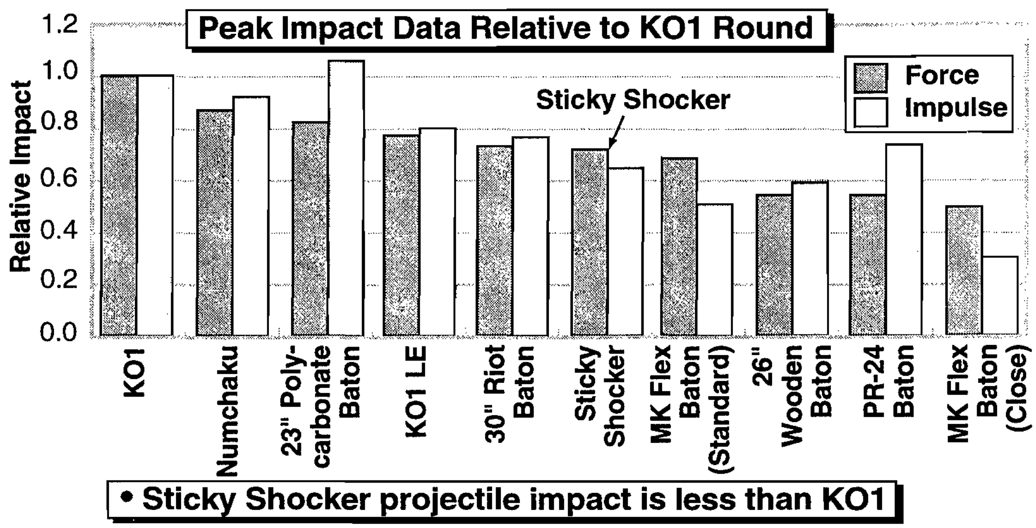

Figure 7. Representative impact/impulse from blunt trauma less-lethal weapons and the Phase One Sticky Shocker demonstration projectile.

USER DEMONSTRATIONS

Within the development phase, Sticky Shocker was demonstrated at User Evaluation presentations. These demonstrations showed that the Sticky Shocker: could fly to a target at 30 feet, attach, turn on and turn off automatically; could shock through a layer of leather and clothing; and finally that the Sticky Shocker could be fired from various currently used military and law enforcement weapons, such as those shown in Figure 8. It appears that, with additional development, the Sticky Shocker could operate at ranges well beyond 30 feet.

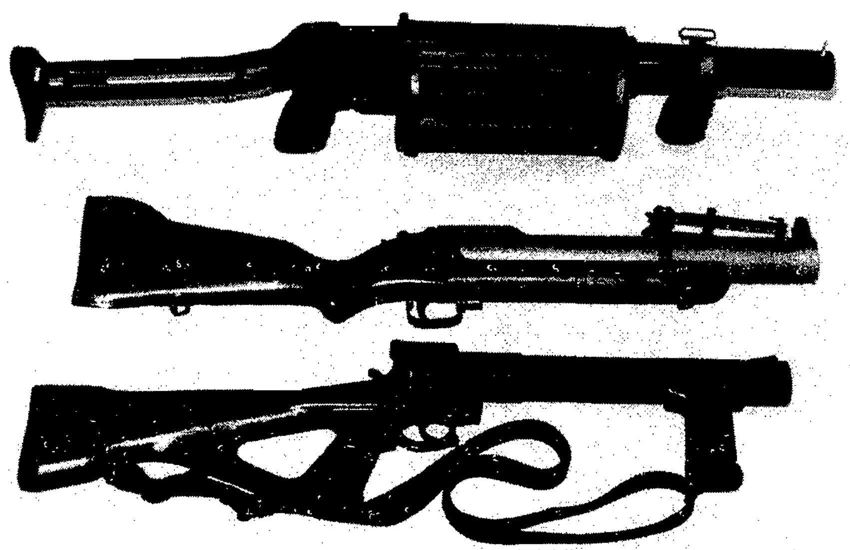

Figure 8. Sticky Shocker is compatible with conventional, military, and law enforcement weapons.

CONCLUSION

The Sticky Shocker projectile shows promise as a new non-lethal projectile. The projectiles produced in the development phase were accurate, stuck on impact, and produced electrical pulses through clothing. Efforts are focusing on further refinements to the manufacturability, and field tests of production units. Manufacturability means that the cost to produce is minimized, that the projectiles are robust (feature a long shelf life and operate through extremes in the environment), and that they are easy to use (load and shoot). The Sticky Shocker projectile is compatible with many existing military launch platforms and in a form useful to law enforcement personnel. The Sticky Shocker projectile adds a new option to non-lethal technology.

REFERENCES

1. Taser, Taser Systems, Inc.
2. Air Taser, product of AIR TASER, Inc., Scottsdale, AZ 85260.
3. Myotron, Arianne Foundation, P.O. Box 32112, Palm Beach Gardens, FL 33410.
4. Underwriters Laboratories, "Electric Shock - A Safety Seminar on Theory and Prevention," UL , Chicago, IL ,1988.
5. International Electrotechnical Commission, Effects of Current Passing Through the Human Body, Part 2: Special Aspects, Publication 479-2, IEC: Geneva, Switzerland, 1987.
6. Sticky Foam, Sandia National Laboratories.
7. MK Flex Baton, MK Ballistic Systems, Hollister, CA 95023.