Non-Lethal Defense III

Non-Lethal Weapons

An Acoustic Blaster Demonstration Program

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Statement of the Problem

PRIMEX Physics International Company (PPI), is developing an Acoustic Blaster (patent pending) that is a credible, cost effective and simple way to employ non-lethal technology in situations in which deadly force is now an unacceptable alternative. The Acoustic Blaster is a highly and/or omni directional sound source which can be used (1) for area denial, and (2) against selected groups of crowds, intruders, mobs, and rioters in a hostile situation. Our device is compact and easily operated by one person. It can be mounted on existing platforms such as the HMMWV as shown in Figure 1.

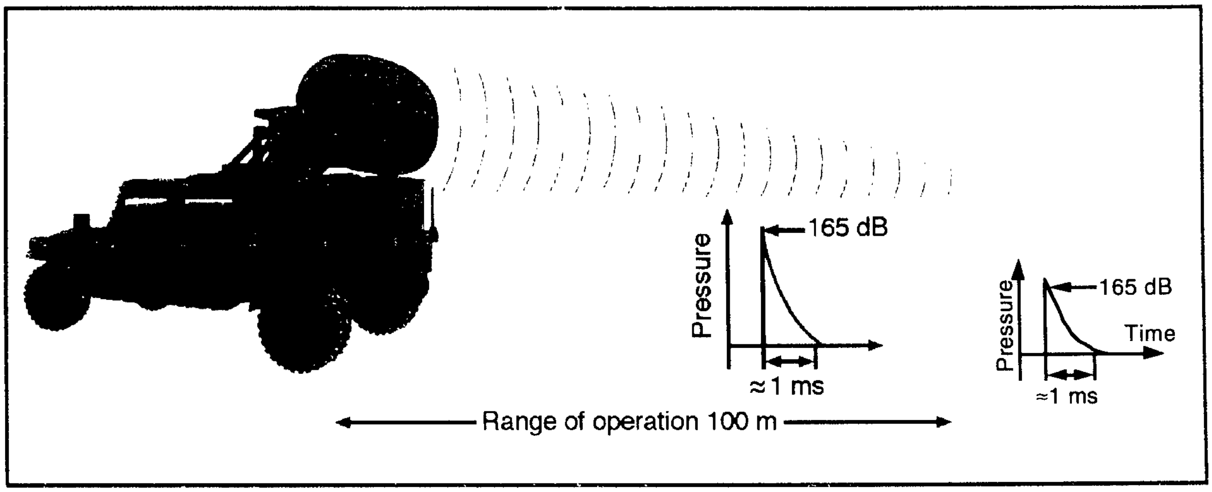

Figure 1. Acoustic Blaster Non-Lethal Device.
Deployed configu ion (engineer's conceptual drawing) of the Acoustic Blaster. Blaster will provide sufficient acoustic pressure to induc pain for personnel control up to 100 m range.

An Acoustic Blaster demonstration program is currently underway at PRIMEX Physics International. A prototype blaster, consisting of an array of four (4) combustion detonation-driven devices has been developed and tested successfully (Figure 2). The prototype containing the four acoustic devices are capable of being fired simultaneously or independently. The most encouraging result thus far, is that acoustic pressure up to 165 dB at 50 ft. from the source has already been achieved. Equally important is that the output pressure waveform of the prototype blaster shown in Figure 3, appears to contain very desirable risetime and pulsewidth characteristics that are essential for optimal acoustic-physiological coupling to targets for anti-personnel applications.

Technical Approach

The key element of the Acoustic Blaster is a planar array of multiple acoustic pulsed sources, each of which is capable of independent operation and each of which generates an independent primary pressure pulse. Figure 4 is a schematic diagram of the system with an elliptic array of individual sources.

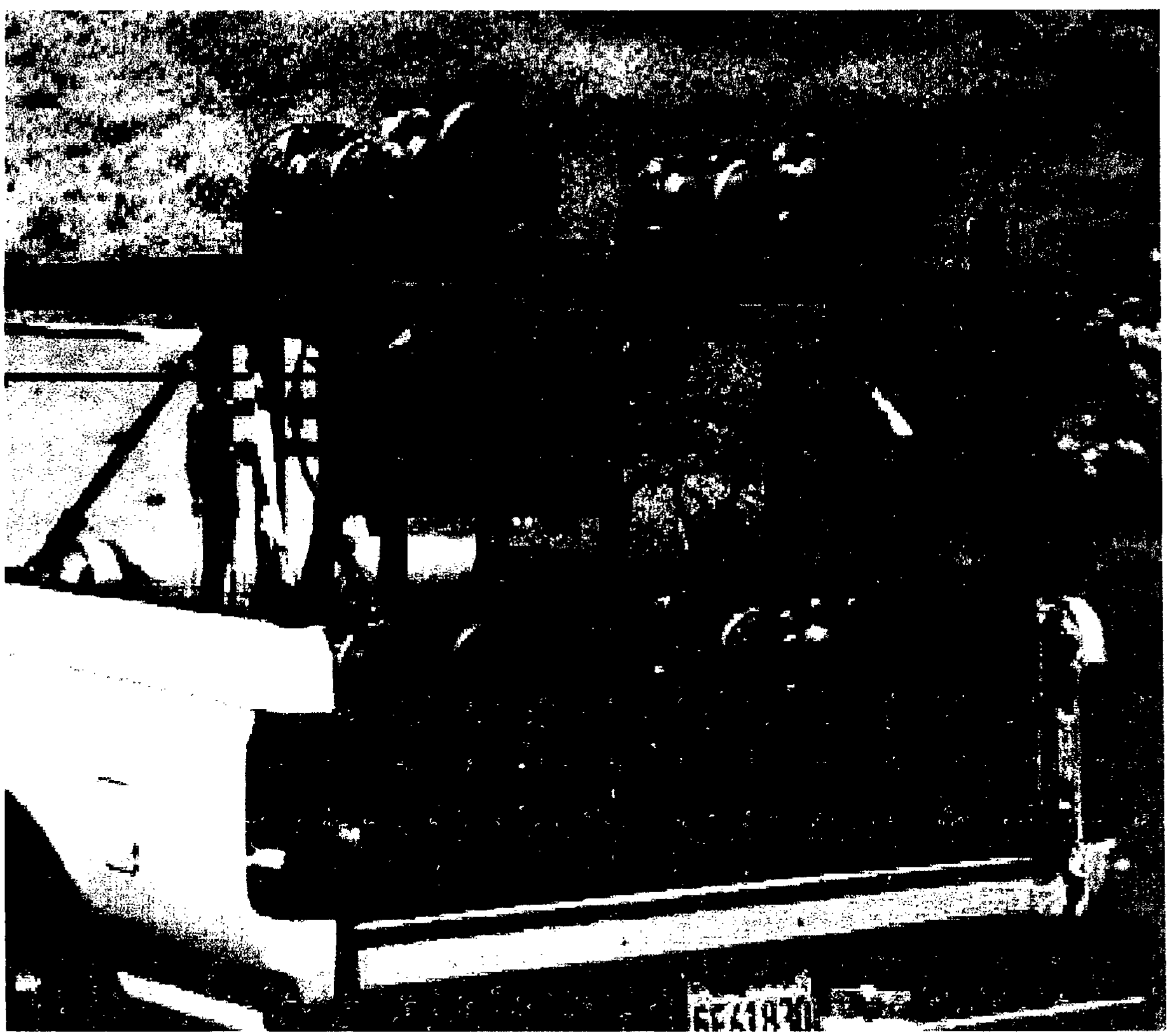

Figure 2. The Truck-Mounted PPI Acoustic Blaster.

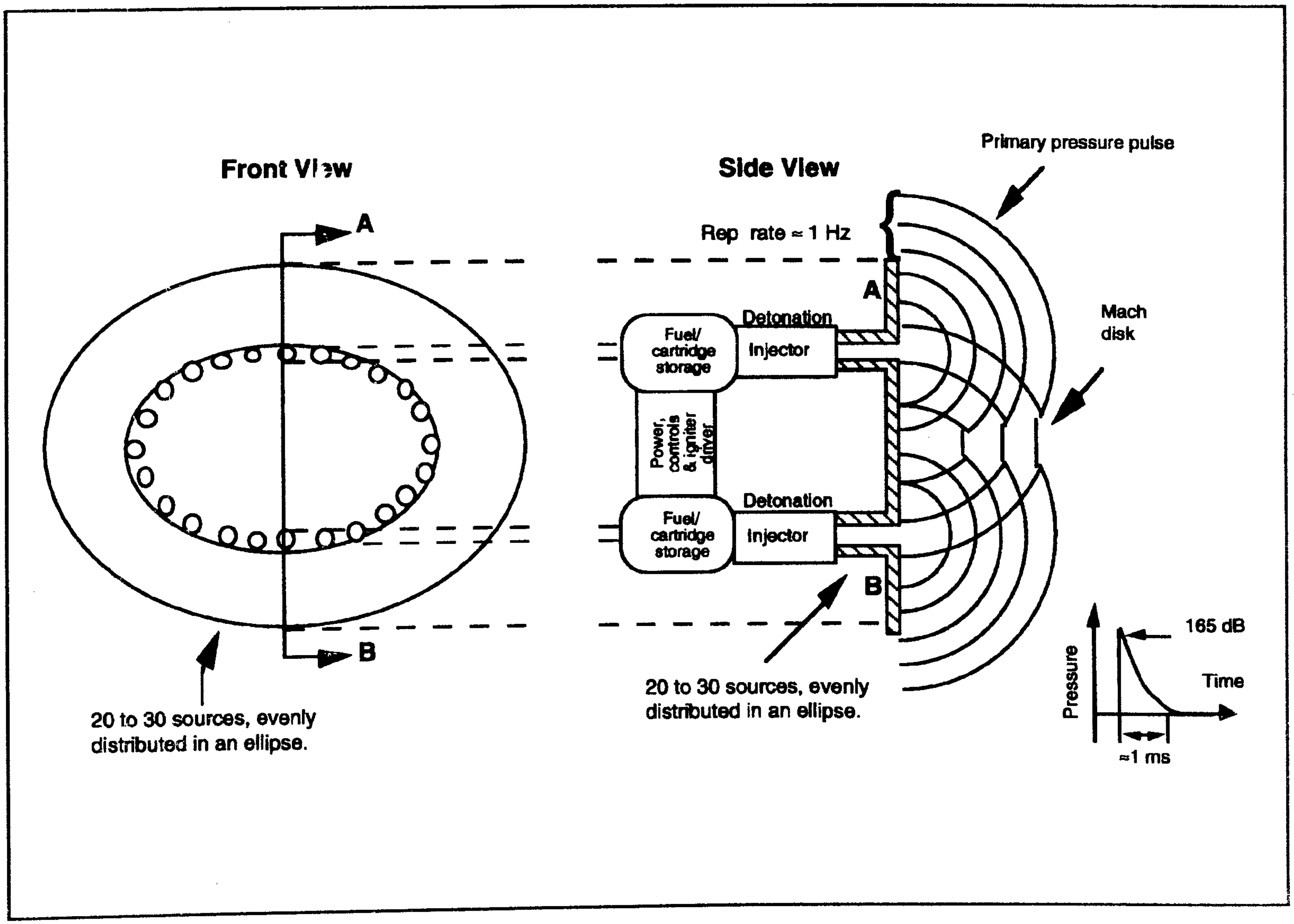

Figure 4. Acoustic Cannon Planar Array Detail - Front and Side Views.
(Sample energetic materials: detonation-driven sources or explosive charges.)

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Figure 5 shows the pressure levels generated on the centerline by the proposed Blaster at ranges up to one kilometer for various masses of energetic material (in equivalent mass of TNT) expended in the entire array. We generate the data in this figure using results from a linear analysis which provides a conservative lower bound on the pressure magnitudes. Due to the unique phased array effect of the addition of the individual pulses along the center line, the linear pressure in the combined pulse is $n^{2/3}$ times the pressure of a pulse generated by one single source with equal amount of energetic material. This gain is analogous to the power density gain of a phased array of microwave antennas. The indicated pressure levels cause disorientation and debilitation at ranges of 100 to 200 m. All levels are less than lethal.

Threshold of pain (CW)
- Infrasound (50-100 Hz): 145 dB *(subjectively intolerable)*
- Human hearing range: 150 dB
- Airborne ultrasound: heating effects (long exposures) @>175 dB

Rupture of human tympanic membrane
(age and individual dependent)
- Minimum: 185 dB (5-6 psi)
- Average: 195 dB (23 psi)

Pulmonary injury (3 ms. pulse)
- Onset: 200 dB (30 psi)
- Lethality: 220 dB (100 psi)

Impulse force (2 mph jolt)
- Diffraction phase: 90 psi
- Drag phase: depends upon duration (many ms. required)

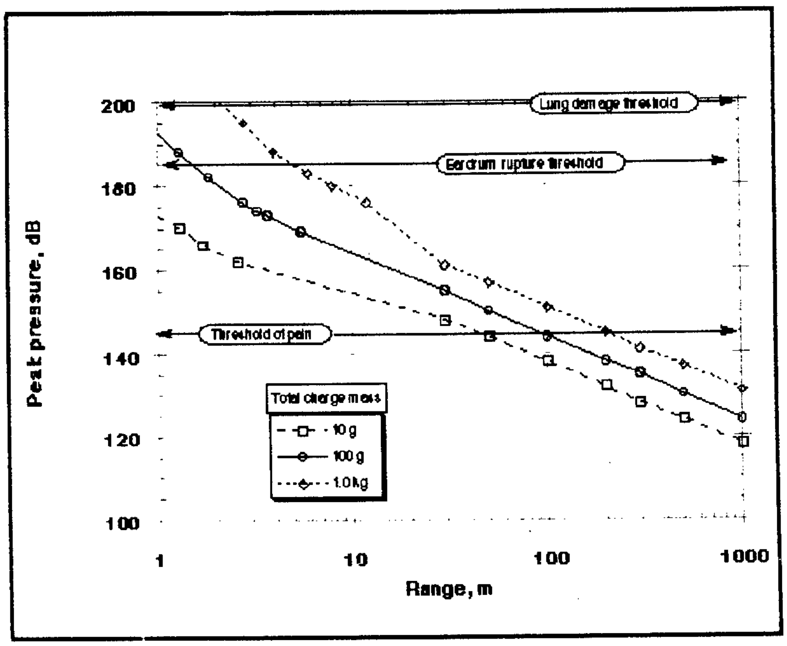

Figure 5. Physiological Effects of Intense Sound.

Preliminary **non-linear** analyses show that there are three major advantages to using "n" multiple individual pulses rather than one strong pulse. First, the formation of a non-linear shock wave (Mach disk or acoustic soliton) will likely lead to significant intensity enhancement. The radial extent of the Mach disk is limited, which allows the system to focus the high intensity pulse over a small area at ranges of order 100 m. Second, the intensity in the mach disk falls off more slowly with distance than the inverse-range-squared behavior of a single, spherically expanding pulse. Third, the temporal width in the Mach disk (sketch in the lower right corner of Figure 4) is the same as that in the individual pulses. Since the width of a pulse increases as the one-third power of its initial energy, the composite pulse delivers its energy in a shorter time (higher power, therefore, higher peak pressure) compared to a monolithic pulse with the same initial energy.

An initial review of the literature on the biologic effects of high intensity sound indicates that the magnitude of these effects depends not only on the peak pressure but also on the pulse risetime, the pulse width and the pulse repetition frequency.

The risetime of pressure is a threshold effect – all pulses with a risetime short compared to the transit time over the target will have the same desired effect. This time is approximately 100 μs, which is long compared to the pressure risetime in a strong shock wave.

Pulse width requirements for maximum effect vary but are generally on the order of one msec. This requirement is well matched to the propagation and evolution of intense sound waves. Frequencies below 2000 Hz disperse rapidly from the sources. On the other hand, frequencies above 5000 Hz are rapidly attenuated by molecular dissipation. The duration of the positive pressure phase of the pulse, which may be critical to effects coupling, becomes stable at distances beyond 10 m.

The pulse width depends on the energy release in the acoustic elements and is controlled through the amount of energetic material, its composition (i.e., burn rate) and its geometry. Since peak pressure at a given range depends on the initial amount of material used, simultaneous control of pulse width and magnitude involves varying both the amount of material and the number of source elements per shot.

The effects literature suggests that the biologic effects are sensitive to the pulse repetition rates. We estimate this rate to lie between one-fifth and one Hz. However, we do not consider this to be a critical design parameter because it is possible to operate the system at rates up to several Hz.

Initial system configuration analyses have identified several possible candidates for the energetic acoustic source material. Five examples are: 1) a pulsed detonation device or advanced shock tube which produces extremely high pressure in small volumes; 2) a pumped liquid, such as liquid propane, mixed with high pressure air; 3) a liquid bi-propellant such as hydroxyl; 4) a fast burning solid material, such as pistol powder, in a combustible cartridge; and 5) noisy spark-gaps which allow an all-electric system configuration. All five technologies are "clean" in the sense that no residue or waste material remains at the site of operation. Trade studies will consider the advantages and disadvantages of each approach.

To summarize, we have reached our first milestone to develop and test a prototype Acoustic Blaster for non-lethal area denial and/or crowd control applications. We are poised to begin an engineering optimization and product implementation program to provide a credible, cost effective and simple acoustic device for many non-lethal military and law enforcement applications.

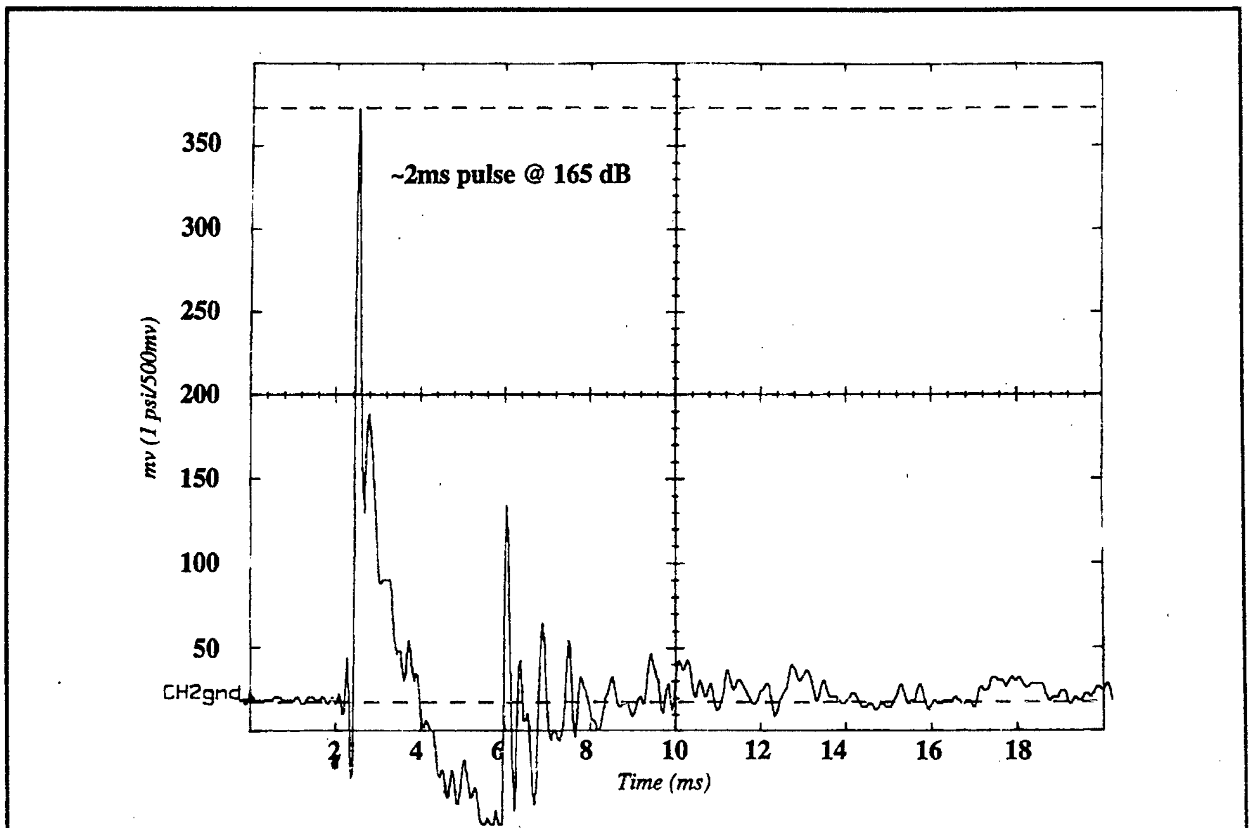

Figure 3. Acoustic Pulse Shape.
Time vs. Acoustic Pressure @ 50 ft. from source.