illustrated showing the high pressure region **76** and low pressure region **78**. Shortly after rupture of the frangible diaphragm **74**, a shock wave **82** begins to traverse the low pressure region **78**. Trailing the shock wave **82**, but traveling at a higher velocity is a rarefaction wave **84**. As indicated in FIG. **4**E, adjacent to the output end **80**, the rarefaction wave **84** catches up with the shock wave **82**, generating a high energy sonic pulse.

FIG. **5** illustrates the incorporation of a shock tube **72** into the acoustic cannon of the invention. The shock tube **72** has a high pressure region **76** and low pressure region **78** separated by a frangible diaphragm **74**. Prior to actuation, both the high pressure region **76** and low pressure region **78** are at substantially the same pressure. Preferably, prior to actuation, both regions are filled with air at ambient pressure. Frangible diaphragm **74**, typically a thin sheet of plastic or other brittle material, is inserted into a notch formed through the housing **86** of shock tube **72** and separates the high pressure region **76** from the low pressure region **78**.

To actuate the acoustic cannon, the gas pressure in the high pressure region **76** is increased by any suitable means. A preferred means is electric arc heating. A first electrode **88** extends longitudinally through a portion of the high pressure region **76** centered about a longitudinal axis **90** of the shock tube **72**. A front end **92** is proximate to the frangible diaphragm **74**, but preferably the front end **92** does not contact the frangible diaphragm **74**. A rear end **94** extends through a rear wall **96** of the high pressure region **76** terminating in a reservoir **98** containing a high dielectric fluid **100** having a resistivity in excess of about 10^6 ohm-cm. One suitable dielectric is conventional transformer oils. The oil is for insulation only, other methods of high voltage insulation are equally suitable.

Encasing a substantial portion of the first electrode **88** is a dielectric insulator **102**. The dielectric insulator **102** covers an entire mid-portion of the first electrode **88**, exposing only a desired small amount of the front end **92** and the rear end **94**.

Disposed about a portion of the dielectric insulator **102** is a second electrode **104**. The second electrode **104** has a front end **106** disposed within the high pressure region **76** and a rear end **108** disposed within the high dielectric fluid **100** of reservoir **98**.

The dielectric insulator **102** defines a longitudinal length, L, between the second electrode **104** and the front end **92**, that regulates heating of the gas contained within the high pressure region **76**.

When the shock tube **72** is actuated, an electric spark **110** is emitted and traverses along the surface of the dielectric insulator **102** from the second electrode **104** to the front end **92** of the first electrode **88**. Increasing the length, L, increases the time that the gases are exposed to the electric spark increasing heating of the gases. As the gases are heated, they expand, generating a pressure differential between the high pressure region **76** and low pressure region **78**. Increasing the length of L, increases the heating of the gases, increasing the expansion thereof, thereby increasing the pressure differential and intensity of the shock wave ultimately emitted from the shock tube.

To actuate the shock tube **72**, a power supply **112** charges a capacitor **114**. The voltage difference between the first electrode **88** and second electrode **104** must exceed the breakdown voltage of the gas contained within the high pressure region **76**. For air, a voltage differential of in excess of 100 kilovolts, and preferably on the order of 150 kilovolts is utilized. A timing mechanism (not shown) actuates all shock tubes **72** of the acoustic cannon at substantially the same time by electronically closing a switch **116**, thereby completing the circuit. Preferably the length L is from about 6 inches to about 36 inches. The spark will traverse a distance in excess of one foot in less than 2 microseconds.

After each burst of the shock tube, the frangible diaphragm **74** must be replaced. The pulse repetition rate is from about 0.1 to about 5 seconds and preferably from about 0.5 to about 2 seconds.

Rapid replacement of the frangible diaphragm is achieved by mechanical means. An advantage with the electric heated shock tube of the invention is that the frangible diaphragm **74** may be omitted. The gas in the high pressure region **76** is heated faster than the pressure can be relieved. The result is a pressured region that expands as a shock wave from the end of the barrel.

The frequency content of the sonic pulses is controlled by the barrel length. The output of the pulsed acoustic source is a single pulse that has Fourier components that range over a range of frequencies. The principal, or dominant, frequency will primarily be dependent on the duration of the high-pressure portion of the pulse, that can be controlled to a first order by the energy in the individual shock sources and by the barrel length.

As illustrated in FIG. **6**, to maintain high directivity, the minimum dominant frequency of the sonic pulses is in excess of about 1 kHz, and preferably in excess of about 2 kHz.

As illustrated in FIG. **7**, attenuation increases as the frequency increases such that the maximum dominant frequency of the sonic pulses is preferably less than about 7 kHz, and more preferably, less than about 5 kHz.

The sound intensity is selected to provide a desired effect to the biological target, dependent on the application. While the effect of sound is subjective and dependent on an individual's physiology, the Table 1 guidelines are illustrative.

TABLE 1

Effect	Sonic Intensity	Shock Wave Pressure
Threshold of Pain	145 dB	
Eardrum Rupture	185 dB	5–6 psi
Pulmonary Injury	200 dB	30 psi
Lethality	220 dB	100 psi

As graphically illustrated in FIG. **8**, a sonic generator having a mass equivalent to the "total charge mass" equivalency of trinitrotoluene (TNT) is capable of producing a shock pulse effective to cause disorientation and debilitation, without permanent injury, over distances of from less than 10 meters to in excess of 100 meters. The FIG. **8** distances were computed based on a single sonic source and do not include the $n^{2/3}$ factor that is obtained using multiple sources. As such, FIG. **8** illustrates the minimum over-pressure values at a given range for different values of the source strength (energy). Incorporation of the $n^{2/3}$ factor for multiple sources substantially increases the effective range for a given over-pressure level.

It is anticipated that the acoustic cannon of the invention will weigh less than 50 kilograms and occupy a net volume of about 1 cubic meter, compatible with current light infantry vehicles.

The discrete nature of the individual pulses comprising the acoustic radiation field essentially eliminates the pres-