The Front View (FIG. 2A) illustrates the output ends **24** arranged in a generally planar array having symmetry about a central point **36**. The planar array may be configured as any shape, with symmetric shapes preferred to optimize the sonic output. A most preferred configuration is elliptical, including circular, arrays. The number of output ends **24** in the planar array is at least two to provide directivity and at least three to provide a symmetric array. Preferably, there are at least four output ends **24** in the planar array. More preferably, there are from about 10 to about 40 output ends and most preferably, from about 20 to about 30 output ends.

As illustrated in the Side View (FIG. 2B), when sonic pulses of substantially the same amplitude and duration are emitted from each of the output ends **24** at essentially the same time, the shock waves **37** interact along a longitudinal axis **38**, running parallel to the longitudinal axis of the interior bore **26** and extending outwardly from the central point **36**. Interaction of the shock waves **37** from the plurality of output ends **24** generates a Mach disk **39**. The output has some of the characteristics of an acoustic soliton, although while a soliton does not change shape with propagation, the shock-driven output pulses of the invention are expected to undergo relatively slow and predicable changes in shape.

The Mach disk is a non-linear shock wave that travels rapidly along the longitudinal axis **38** with limited radial diffusion over distances of up to 100 meters. The intensity of the shock wave **37** contained within the Mach disk **39** decreases more slowly over distance and time than the $1/(\text{range})^2$ behavior of a single spherical expanding pulse.

If the same energy is used in a multiple tube source having a planar array of outputs as in a single output source, the on-axis peak pressure for the multiple tube source, in the direction of maximum directivity, is $n^{2/3}$ times that of the single tube. The $n^{2/3}$ factor is derived from a linear superposition of the predicted pressure pulses from individual sources, which will all be of shorter duration than a single pulse derived from a single source using the same total energy. With multiple sources, energy from each individual source is concentrated in a shorter on-axis pulse. At the same range from the array, the resulting peak pressure is greater by this factor compared to the peak pressure associated with a single source of equivalent total energy. The attenuation rates of the peaks with distance will be essentially the same for single and multiple sources.

For a 10 tube array having the same output energy as a single tube, the sound pressure, along the longitudinal axis, is 4.6 times higher than for the single tube at similar times and distances.

FIG. **3** illustrates in cross-sectional representation an acoustic source **40** for use with the acoustic cannon of the invention in accordance with one embodiment. The acoustic source **40** has an input end **42** and an output end **44**. The input end **42** receives sonic pulses and the output end **44** transmits the sonic output as a portion of a planar array of outputs to generate a Mach disk.

Coupled to the input end **42** is a sonic pulse generator **46**. The sonic pulse generator **46** detonates an explosive mix of gases or vaporized liquids. A first fluid component, that could be a gas, a liquid, or a mixture thereof, is delivered to a mixing chamber **48** through a first conduit **50**. A second fluid component is delivered to the mixing chamber **48** through a second conduit **52**. A first fluid control valve **54** and a second fluid control **56** determine the ratio of first fluid to second fluid in the mixing chamber **48**. While stoichiometric ratios of the fluids are preferred, a stoichiometric ratio is not required. Any fluid mix ratio that generates an explosive shock wave on ignition is suitable. A third fluid control valve **58** introduces a desired volume of mixed fluid into the barrel **60** of the acoustic source **40**. The desired volume of fluid substantially fills the barrel **60**.

The fluid control valves **54,56,58** are any suitable type of fluid metering system. Since the first fluid control valve **54** and the second fluid control valve **56** control fluid ratios, adjustable manual valves are suitable. The third fluid control valve **58** accurately and repeatedly delivers the mixed fluid to barrel **60**. Rapid repetition rate is frequently required and the third fluid control valve **58** is preferably an electrically actuated solenoid valve.

A power supply **62** generates a voltage potential between electrodes **64** that exceeds the breakdown voltage of the mixed fluid contained within the barrel **60** thereby generating a spark at gap **66**. An effective voltage potential is from about 10 kilovolts to about 100 kilovolts. To optimize generation of the Mach disk, the interior bore of the barrel **60** is preferably symmetric about a longitudinal barrel axis **68**. More preferably, the interior bore is circular in cross-section and the spark gap **66** aligned along the longitudinal axis **68**.

A timing mechanism **70** is coupled to the sonic pulse generator and controls power source **62**, third fluid control valve **58**, or preferably, both devices. The timing mechanism **70** ensures that each of the plurality of acoustic sources is fired at substantially the same time for effective generation of the Mach disk.

A number of different fluid combinations produce effective shock waves that exit the acoustic source **40** as a strong sonic pulse. Preferred fluids are combinations of gases and include hydrogen/oxygen, oxygen/propane, air/propane, air/acetylene, oxygen/acetylene and the like. A preferred explosive fluid mixture is hydrogen and oxygen in approximately stoichiometric quantities (atomic ratio of H:O of 2:1). For this mixture, a voltage pulse in the range of from about 30 kilovolts to about 50 kilovolts, and typically about 40 kilovolts, for a duration of 1 microsecond is effective. Atomized or vaporized liquid fuels such as gasoline, can also be mixed with oxygen or air as an effective mixed fluid.

Rather than mixed fluids to generate the sonic pulse on detonation, solids fuels can be used. The solid fuels would be packaged in a manner similar to blank shells, but would be larger and have more energy per package than the usual gun blanks. An electronic squib or a percussive primer is used to detonate the solid fuel. Automatic reloading of the solid fuel shells could be accomplished in a manner that is conventional for guns or cannons to accomplish a desired repetition rate.

A most preferred acoustic source is an electrically triggered shock tube. Shock tubes are disclosed in U.S. Pat. No. 3,410,142 to Daiber et al. that is incorporated by reference in its entirety herein. With reference to FIG. 4A, the shock tube **72** is tubular with an interior bore centrally running therethrough. A frangible diaphragm **74** separates the shock tube **72** into a high pressure region **76** and a low pressure region **78**. When frangible diaphragm **74** is ruptured, the pressure differential between the high pressure region **76** and the low pressure region **78** generates a shock wave that travels the length of the low pressure region **78** and is emitted from the shock tube **72** at output end **80** as a sonic pulse.

FIGS. 4B through 4E illustrate the generation of the sonic pulse. In FIG. 4B, the initial pressure distribution of the shock tube prior to rupture of the frangible diaphragm **74** is