

**A LOW FREQUENCY COMPACT PNEUMATIC SOUND SOURCE**

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**ABSTRACT**

The Low-frequency Acoustic Waveguide Source (LAWS) is an underwater pneumatic source which uses the properties of a bubble plume in deep water to enable an acoustically compact transducer to generate low frequency sound. A bubble plume containing a mixture of gas bubbles with water may be generated in deep water. The plume typically contains a high volume fraction of gas near to its base, but as the bubbles rise through the water the width of the plume increases and the gas dissolves, so that the volume fraction of gas reduces. Typically at 50 metres above the base of the plume, the gas dissolves completely and the plume terminates. It is well known that the speed of sound in water containing bubbles may be substantially lower than in water without bubbles. The acoustical impedance, given by the product of density and sound speed, is significantly lower than that for water near the base of the plume; it rises along the axis of the plume and becomes equal to that of the surrounding water at the termination of the plume. In addition, it can be shown that the low sound speed causes sound generated at or near the base of the plume to be trapped within the plume; the sound increases in speed as it passes along the plume and finally is efficiently radiated into the water at the plume's termination. The plume therefore acts as an acoustic transformer where large displacements caused by small forces acting on the base of the plume translate to large forces at small displacements in the surrounding water; the behaviour is analogous to a horn transducer in air. If the same compressed gas is used to both form and modulate the plume the device may be very compact.

Analytical results are presented which show that it might be possible by this approach to generate sound at frequencies down to a few Hz, and experimental results are given for a 200 Hz transducer in 90 metres of water.