Analog Binaural Circuits for Detecting and Locating Leaks

Ultrasonic signals received by paired transducers would be correlated to measure differential delays.

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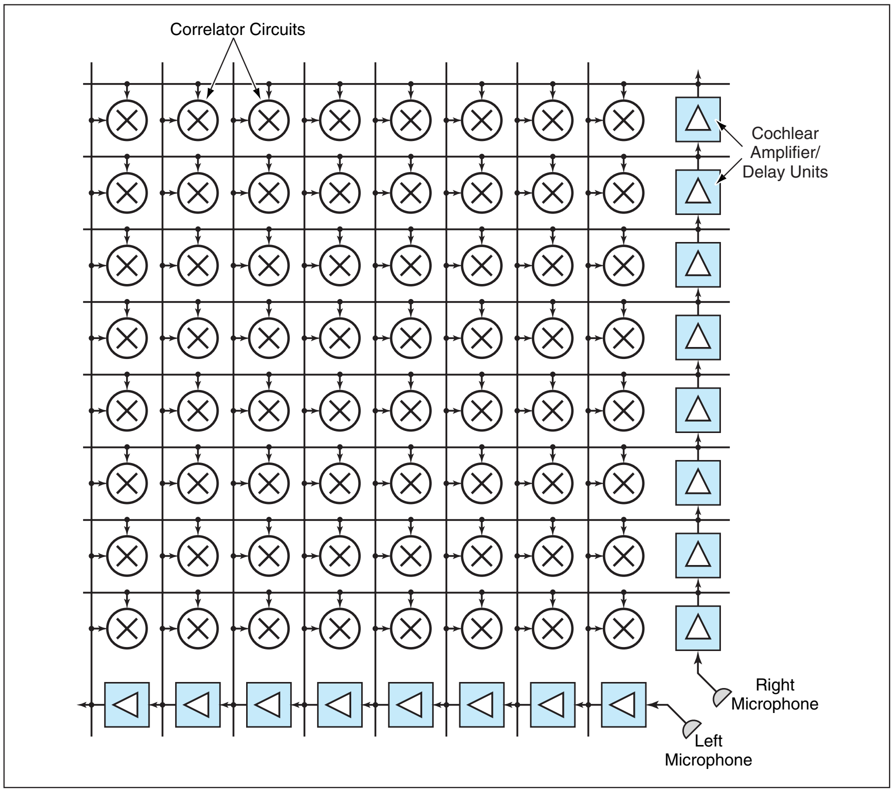
Very-large-scale integrated (VLSI) analog binaural signal-processing circuits have been proposed for use in detecting and locating leaks that emit noise in the ultrasonic frequency range. These circuits would be designed to function even in the presence of intense lower-frequency background noise that could include sounds associated with flow and pumping. Each of the proposed circuits would include the approximate electronic equivalent of a right and a left cochlea plus correlator circuits.

A pair of transducers (microphones or accelerometers), corresponding to right and left ears, would provide the inputs to their respective cochleas from different locations (e.g., from different positions along a pipe). The correlation circuits plus some additional external circuits would determine the difference between the times of arrival of a common leak sound at the two transducers. Then the distance along the pipe from either transducer to the leak could be estimated from the time difference and the speed of sound along the pipe. If three or more pairs of transducers and cochlear/correlator circuits were available and could suitably be positioned, it should be possible to locate a leak in three dimensions by use of sound propagating through air.



Cochlear and Correlator Circuits, operating in conjunction with external scanning circuits, would implement stereausis.

The cochlear circuits would consist mostly of cascades of amplifier/delay units positioned along two orthogonal edges of a rectangular VLSI chip, as depicted in the figure in simplified form. In addition to introducing increments of delay, the cochlear circuits would filter the signals to reject frequencies below the ultrasonic range. The output of a given amplifier/delay unit in a cochlea would be fed to both the next amplifier/delay unit in the same cochlea and to a string of correlator circuits, which would form the analogs of the correlations between (1) the output of this unit and (2) the outputs of all amplifier/delay units in the other cochlea. The outputs of the correlator circuits would be scanned by the external circuitry and displayed or otherwise processed to determine which pairings of right and left cochlear units (and thus which differential signal delay) yields the greatest correlations.

This work was done by Frank T. Hartley of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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Mirrors Containing Biomimetic Shape-Control Actuators

Local bending would be controlled to obtain desired surface figures.

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Curved mirrors of a proposed type would comprise lightweight sheets or films containing integral, biologically inspired actuators for controlling their surface figures. These mirrors could be useful in such applications as collection of solar energy, focusing of radio beams, and (provided sufficient precision could be achieved) imaging. These mirrors were originally intended for use in outer space, but it should also be possible to develop terrestrial versions.

Several prior *NASA Tech Briefs* articles have described a variety of approaches to the design of curved, lightweight mirrors containing integral shape-control actuators. The primary distinction between the present approach and the prior ap-

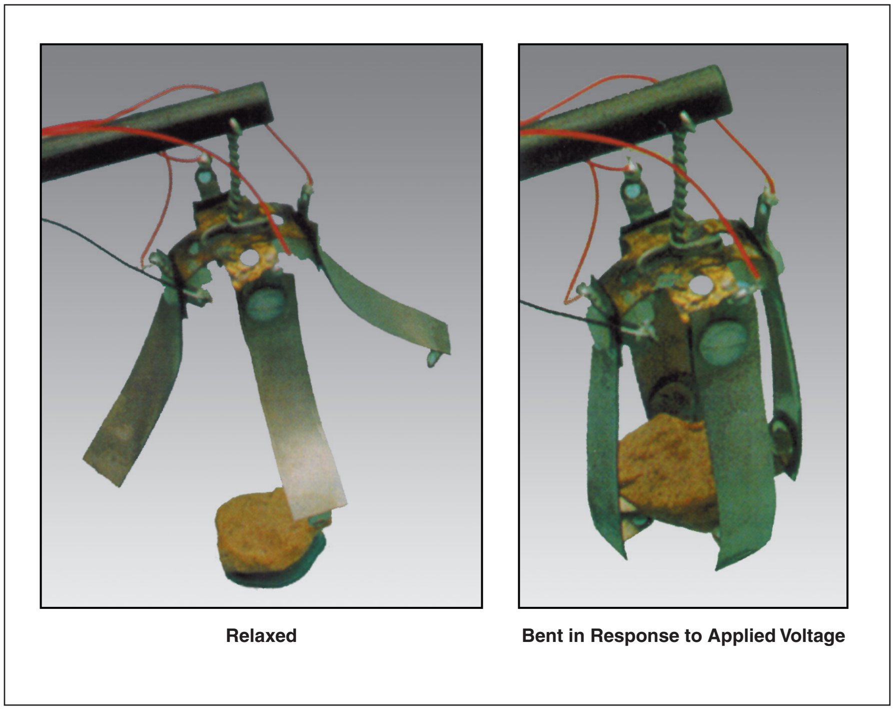

Figure 1. **IPMC Multifinger Grippers** have been adopted as models from which designs of proposed shape-controllable mirrors would be developed.

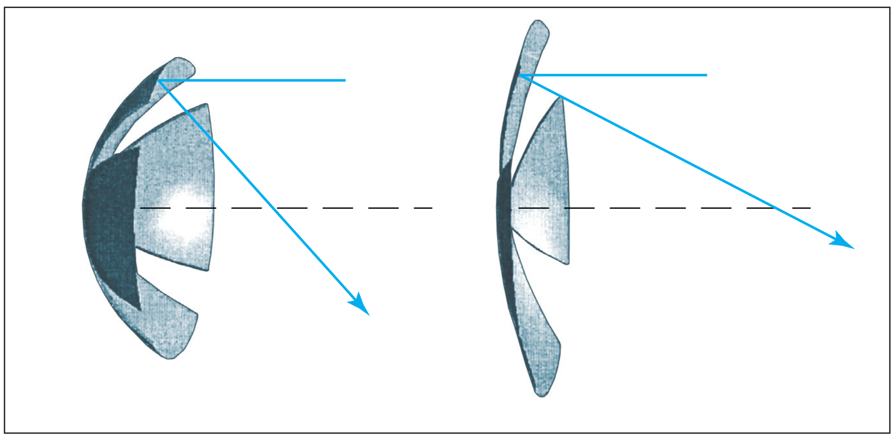

Figure 2. The **Focal Length of a Curved Mirror** would be varied by using its shape actuators to vary its curvature.

proaches lies in the actuator design concept, which involves shapes and movements reminiscent of those of a variety of small, multi-armed animals. The shape and movement of an actuator of this type can also be characterized as reminiscent of that of an umbrella. This concept can be further characterized as a derivative of that of multifinger grippers, the fingers of which are bimorph bending actuators (see Figure 1). The fingers of such actuators can be strips containing any of a variety of materials that have been investigated for use as actuators, including such electroactive polymers as ionomeric polymer/metal composites (IPMCs), ferroelectric polymers, and grafted elastomers.

A mirror according to this proposal would be made from a sheet of one of the actuator composites mentioned above. The design would involve many variables, including the pre-curvature and stiffness of the mirror sheet, the required precision of figure control, the required range of variation in focal length (see Figure 2), the required precision of figure control for imaging or non-imaging use, the bending and twisting moments needed to effect the required deformations, and voltage-to-moment coefficients of the actuators, and the voltages accordingly required for actuation. A typical design would call for segmentation of the electrodes on the actuators so that voltages could be applied locally to effect local bending for fine adjustment of the surface figure.

This work was done by Yoseph Bar-Cohen, Pantazis Mouroulis, Xiaoqi Bao, and Stewart Sherrit of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
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