Pneumatically Actuated Miniature Peristaltic Vacuum Pumps

Small, rugged, low-power pumps could be fabricated inexpensively.

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Pneumatically actuated miniature peristaltic vacuum pumps have been proposed for incorporation into advanced miniature versions of scientific instruments that depend on vacuum for proper operation. These pumps are expected to be capable of reaching vacuum-side pressures in the torr to millitorr range (from \( \approx 133 \) down to \( \approx 0.13 \) Pa). Vacuum pumps that operate in this range are often denoted roughing pumps. In comparison with previously available roughing pumps, these pumps are expected to be an order of magnitude less massive and less power-hungry. In addition, they would be extremely robust, and would operate with little or no maintenance and without need for oil or other lubricants. Portable mass spectrometers are typical examples of instruments that could incorporate the proposed pumps. In addition, the proposed pumps could be used as roughing pumps in general laboratory applications in which low pumping rates could be tolerated.

The proposed pumps could be designed and fabricated in conventionally machined and micromachined versions. A typical micromachined version (see figure) would include a rigid glass, metal, or plastic substrate and two layers of silicone rubber. The bottom silicone layer would contain shallow pump channels covered by silicone arches that could be pushed down pneumatically to block the channels. The bottom silicone layer would be covered with a thin layer of material with very low gas permeability, and would be bonded to the substrate everywhere except in the channel areas. The top silicone layer would be attached to the bottom silicone layer and would contain pneumatic-actuation channels that would lie crosswise to the pump channels. This ver-
A proposed microelectromechanical system (MEMS) containing a closed-Brayton-cycle turbine would serve as a prototype of electric-power generators for special applications in which high energy densities are required and in which, heretofore, batteries have been used. The design would be such that the higher pneumatic pressure would be sufficient to push the silicone arches down onto the substrates, blocking the channels. Thus, by connecting pneumatic-actuation channels to the two pneumatic sources in spatial and temporal alternation, waves of opening and closing, equivalent to peristalsis, could be made to move along the pump channels.

A pump according to this concept could be manufactured inexpensively. Pneumatic sources (compressors and partial vacuum sources) similar those needed for actuation are commercially available; they typically have masses of ≈100 g and power demands of the order of several W. In a design-optimization effort, it should be possible to reduce masses and power demands below even these low levels and to integrate pneumatic sources along with the proposed pumps into miniature units with overall dimensions of no more than a few centimeters per side.

The disadvantages of the proposed system are that unlike a battery-based system, it could generate a perceptible amount of sound, and, if it were to burn fuel, then it would also generate exhaust, similarly to other combustion-based power sources.

This work was done by Sabrina Feldman, Jason Feldman, and Danielle Svehla of Caltech for NASA’s Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com. NPO-30165