



Machinery/Automation

Miniature Robotic Spacecraft for Inspecting Other Spacecraft

Lyndon B. Johnson Space Center, Houston, Texas

A report discusses the Miniature Autonomous Extravehicular Robotic Camera (Mini AERCam) — a compact robotic spacecraft intended to be released from a larger spacecraft for exterior visual inspection of the larger spacecraft. The Mini AERCam is a successor to the AERCam Sprint — a prior miniature robotic inspection spacecraft that was demonstrated in a space-shuttle flight experiment in 1997. The prototype of the Mini AERCam is a demonstration unit having approximately the form and function of a flight system. The Mini AERCam is approximately spher-

ical with a diameter of about 7.5 in. (≈ 19 cm) and a weight of about 10 lb (≈ 4.5 kg), yet it has significant additional capabilities, relative to the 14-in. (36-cm), 35-lb (16-kg) AERCam Sprint. The Mini AERCam includes miniaturized avionics, instrumentation, communications, navigation, imaging, power, and propulsion subsystems, including two digital video cameras and a high-resolution still camera. The Mini AERCam is designed for either remote piloting or supervised autonomous operations, including station keeping and point-to-point maneuvering. The prototype has

been tested on an air-bearing table and in a hardware-in-the-loop orbital simulation of the dynamics of maneuvering in proximity to the International Space Station.

This work was done by Steven Fredrickson, Larry Abbott, Steve Duran, Robert Goode, Nathan Howard, David Jochim, Steve Rickman, Tim Straube, Bill Studak, Jennifer Wagenknecht, Matthew Lemke, Randall Wade, Scott Wheeler, and Clinton Baggerman of Johnson Space Center. Further information is contained in a TSP (see page 1).MSC-23669

Miniature Ring-Shaped Peristaltic Pump

Piezoelectrically excited fluid-transport volumes travel around a ring.

NASA's Jet Propulsion Laboratory, Pasadena, California

An experimental miniature peristaltic pump exploits piezoelectrically excited flexural waves that travel around a ring: A fluid is carried in the containers formed in the valleys between the peaks of the flexural waves (see Figure 1). The basic

action of this pump is similar to that described in "Piezoelectric Flexural-Traveling-Wave Pumps" (NPO-19737), *NASA Tech Briefs*, Vol. 21, No. 4 (April 1997), page 66.

What sets the present pump apart

from other pumps that exploit piezoelectrically excited flexural waves is the ring shape, which makes it possible to take advantage of some of the desirable characteristics of previously developed piezoelectric rotary motors. A major advantage of the circular (in contradistinction to a straight-line) wave path is that the flexural waves do not come to a stop and, instead, keep propagating around the ring. Hence, a significant portion of the excitation energy supplied during each cycle is reused during the next cycle, with the result that the pump operates more effectively than it otherwise would.

The principal components of this pump (see Figure 2) include a cover and segmented-ring piezoelectric actuator bonded to one face of a brass ring. The other face of the brass ring is pressed against the cover and against silicone rubber seals that protrude slightly from grooves in the cover. The protrusion is sufficient to maintain sealing at the maximum flexural-wave amplitude expected to occur during operation of the pump. The pattern of grooves and seals is chosen, in conjunction with the pattern of inlet and outlet holes in the

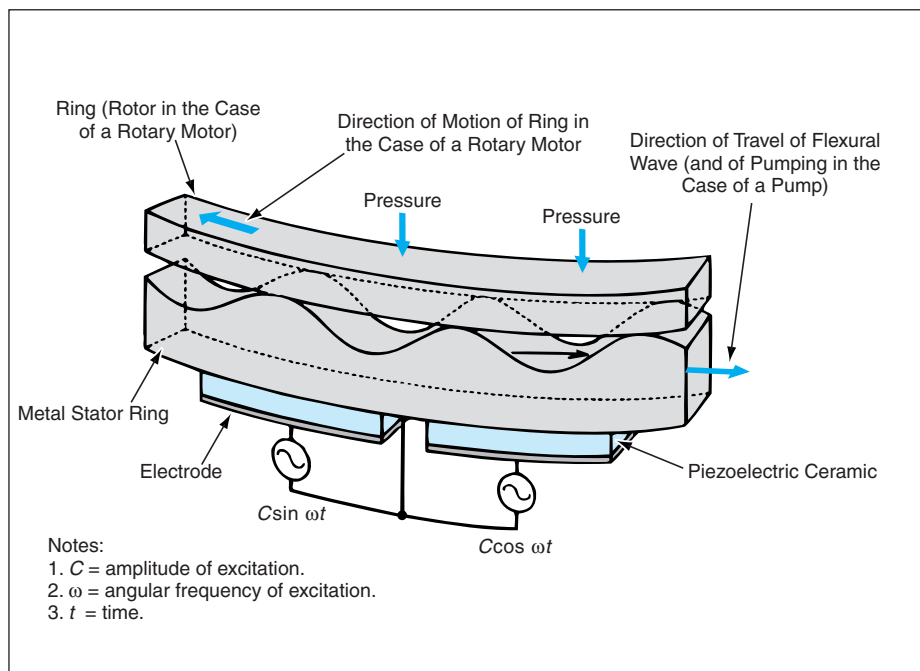


Figure 1. **Traveling Flexural Waves** similar to those in a piezoelectric rotary motor are exploited for pumping. Fluid is carried around a circle in the troughs of the waves.

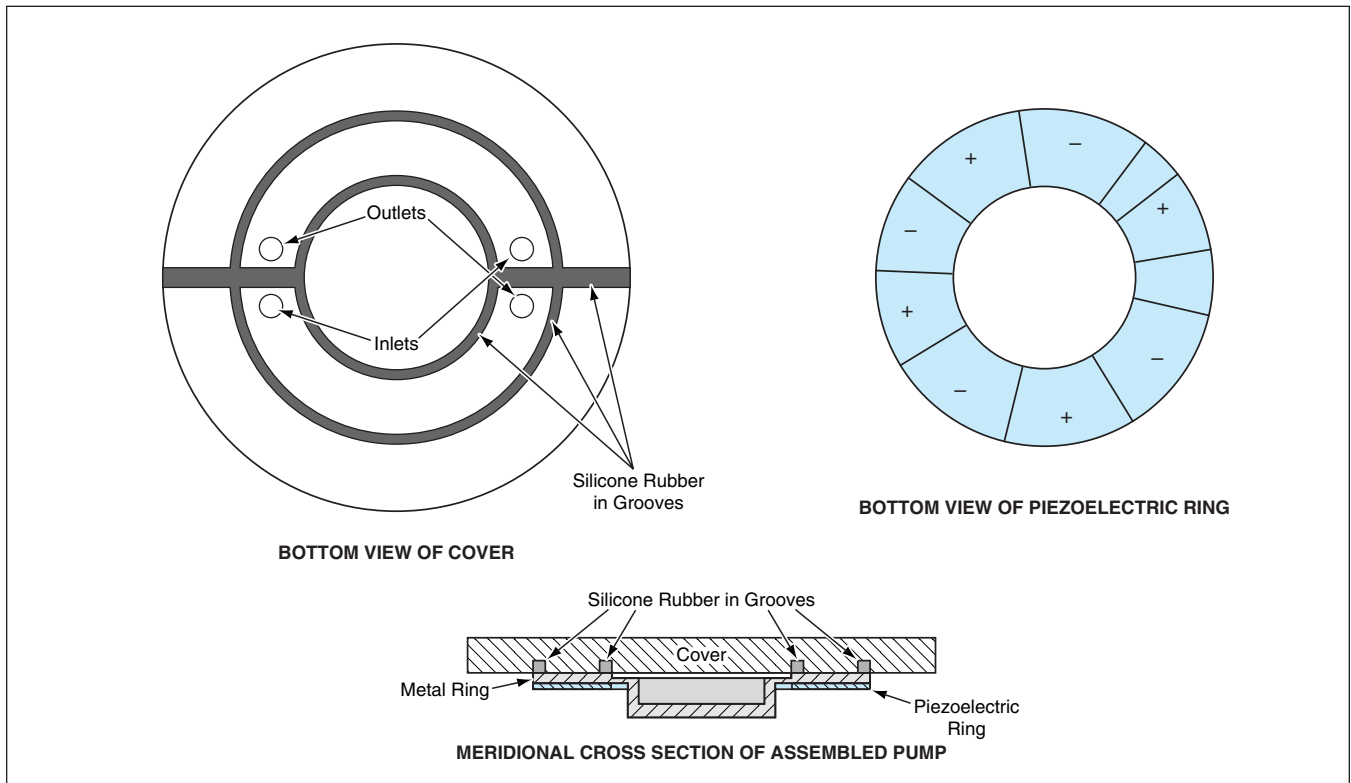


Figure 2. The Ring-Shaped Peristaltic Pump features components designed to maximize the pumping effect depicted in Figure 1.

cover, to eliminate the need for conventional valve mechanisms, sliding seals, and other moving parts that would be highly susceptible to wear. Moreover, when the pump is turned off (that is, in the absence of piezoelectrically actuated flexural waves), the loading of the brass ring against the cover effects a tight seal equivalent to that of a closed valve.

The polarities and phases of the voltages applied to the piezoelectric ring segments are chosen to excite a desired

flexural-traveling-wave mode. For maximum pumping effectiveness, the excitation frequency should equal the resonance frequency of the desired wave mode.

This work was done by Yoseph Bar-Cohen, Zensheu Chang, Xiaoqi Bao, and Shyh-Shiuh Lih of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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Refer to NPO-30415, volume and number of this NASA Tech Briefs issue, and the page number.

⚙️ Compact Plasma Accelerator

Applications could include processing of materials and propulsion of spacecraft.

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A plasma accelerator has been conceived for both material-processing and spacecraft-propulsion applications. This accelerator generates and accelerates ions within a very small volume. Because of its compactness, this accelerator could be nearly ideal for primary or station-keeping propulsion for spacecraft having masses between 1 and 20 kg. Because this accelerator is designed to generate beams of ions having energies between 50 and 200 eV, it could also be used for surface modification or activation of thin films.

The figure illustrates selected aspects of this accelerator. A propellant gas is injected through a feed plenum that is perforated with openings that constitute capillarylike channels in the following sense: They are narrow enough that even at low flow rates, the pressure in them is sufficiently high [a few Torr (a few hundred pascals)] that the depth of channels (the thickness of the plenum wall) is of the order of electron/neutral-atom mean free path. The plenum, which is at anode potential, is centered

above a magnetic cusp generated by a permanent-magnet circuit that consists of ring of magnets surrounding a central magnet.

The magnetic cusp funnels energetic electrons into the plenum openings. These electrons ionize the propellant gas in the channels. Hence, each plenum orifice serves as a very compact, independent discharge cell that provides copious amounts of ions that are subsequently accelerated by sheath potentials. The plasma-production volume, as estimated