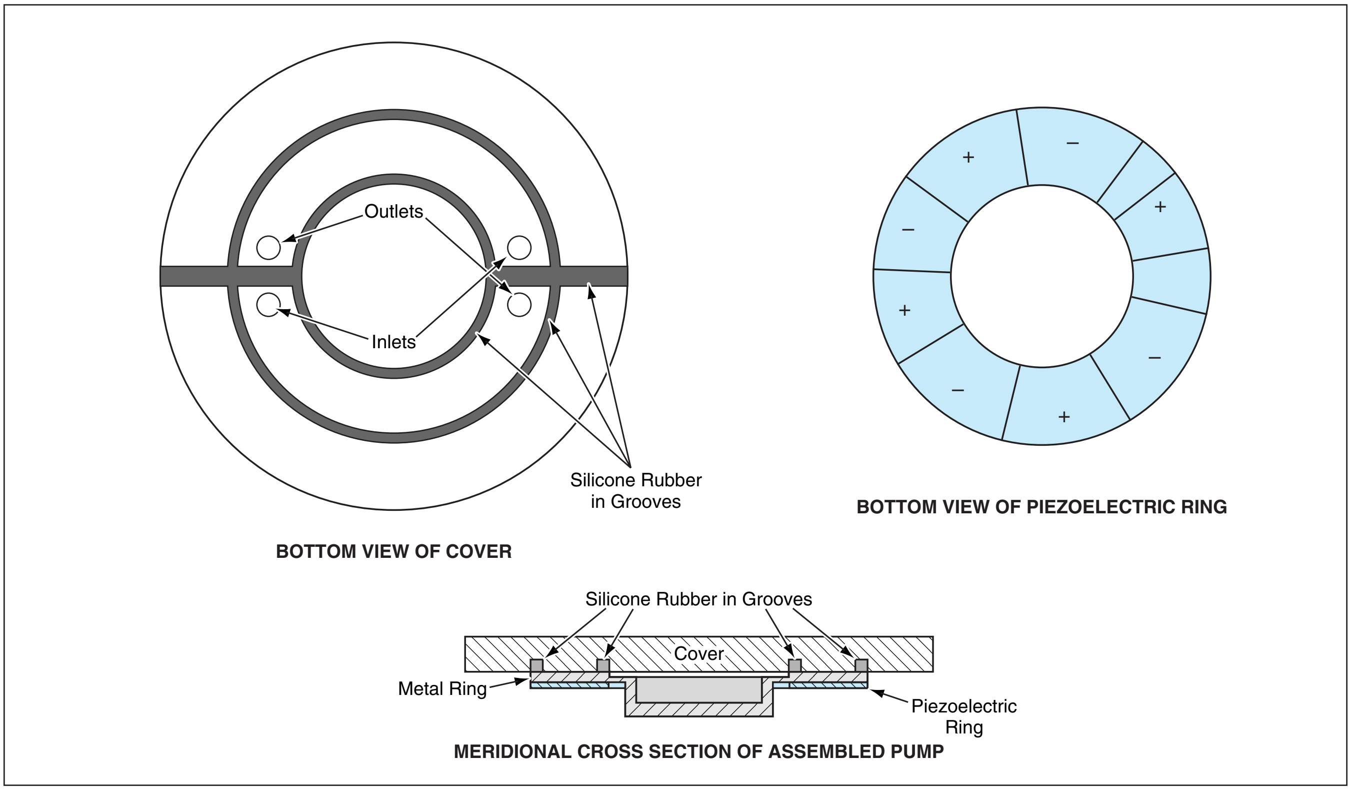

Figure 2. The **Ring-Shaped Peristaltic Pump** features components designed to maximize the pumping effect depicted in Figure 1.

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).*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Compact Plasma Accelerator

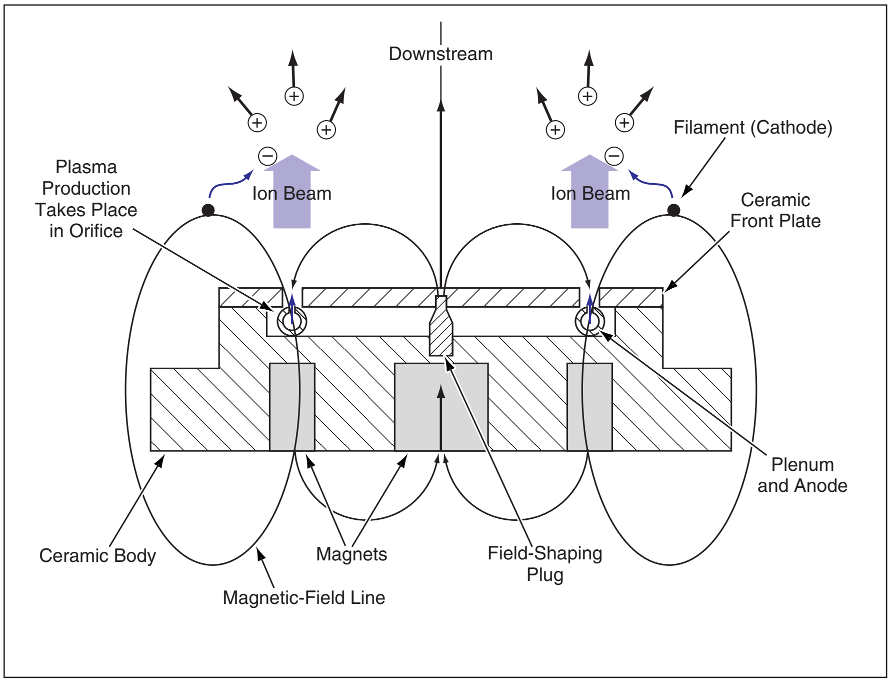
Applications could include processing of materials and propulsion of spacecraft.

John H. Glenn Research Center, Cleveland, Ohio

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



This **Partially Schematic Cross Section** illustrates the design and the principle of operation of the compact plasma accelerator. The device is symmetrical about the z axis.

partly on the basis of the depth of the channels, is of the order of 0.05 mm^3.

The source of electrons is an annular hot filament. This source is located such that emitted electrons must diffuse across the magnetic field to reach the anode. The transverse component of the magnetic field tends to increase the cathode fall voltage. The increase in the cathode fall voltage is necessary for producing energetic electrons for ionization inside the channels. Energetic electrons that have sufficient velocity components parallel to the magnetic field enter the channels to participate in the ionization process. Those without sufficient parallel velocities are reflected by the magnetic-mirror force (a consequence of the chosen magnetic-field configuration and strength). Because the electrons reflected by the mirror force are constrained by the magnetic-field lines, the reflected electrons oscillate between the filament and the plenum. The likelihood that these electrons will ionize neutral atoms in the plenum region increases as this oscillation continues.

Ions formed in the channels are accelerated by the electrostatic-potential gradient across the plasma sheath at the plenum. The ions emitted from the sheath at the anode plenum form an axially directed beam. The ion beam is neutralized by electrons emitted into the beam by the filament. In this respect, the filament provides not only the ionizing electrons but also the neutralizing electrons.

It should be pointed out that the choice of the electron source used in this device is quite general. In the prototype, a coated filament was used. The basic concept of this compact plasma accelerator (CPA) is also compatible with a field-emitter-array cathode. The appeal of the field-emitter approach lies in a higher current density and greater simplicity of integration (no filament heater supply is necessary).

A prototype of this CPA generated a monoenergetic (80-eV) ion beam of 30-mA current at a discharge power of approximately 40 W. The propellant efficiency at this condition was calculated to be approximately 88 percent. The peak ion current densities of the beamlets formed in the prototype CPA were similar to those measured in gridded ion thrusters of much higher power (e.g., 2.3 kW).

This work was done by John E. Foster of **Glenn Research Center**. *Further information is contained in a TSP (see page 1).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17230.

Improved Electrohydraulic Linear Actuators

Advantages include better position control and end-of-stroke buffering.

Stennis Space Center, Mississippi

A product line of improved electrohydraulic linear actuators has been developed. These actuators are designed especially for use in actuating valves in rocket-engine test facilities. They are also adaptable to many industrial uses, such as steam turbines, process control valves, dampers, motion control, etc.

The advantageous features of the improved electrohydraulic linear actuators are best described with respect to shortcomings of prior electrohydraulic linear actuators that the improved ones are intended to supplant. The shortcomings are the following:

- They perform unreliably and inconsistently as positioning devices.
- Their capabilities for end-of-stroke buffering (that is, deceleration to gentle stops at designated stopping positions) range from unsatisfactory to nonexistent, with consequent potential for inducing catastrophic failures.
- It takes long times to manufacture special actuators to meet specifications, and the costs of such actuators are high.

The figure depicts one of the improved actuators. The flow of hydraulic fluid to the two ports of the actuator cylinder is controlled by a servo valve that is controlled by a signal from a servo amplifier that, in turn, receives an analog position-command signal (a current having a value between 4 and 20 mA) from a supervisory control system of the facility. As the position command changes, the servo valve shifts, causing a greater flow of hydraulic fluid to one side of the cylinder and thereby causing the actuator piston to move to extend or retract a piston rod from the actuator body. A linear variable differential transformer (LVDT) directly linked to the piston provides a