

## Miniature Bipolar Electrostatic Ion Thruster

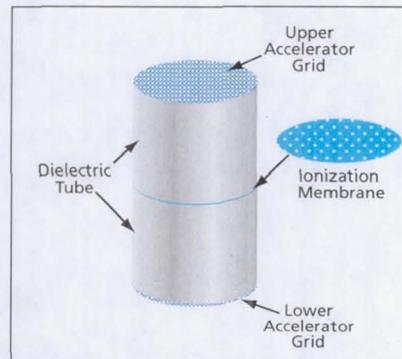
All of the propellant molecules would be ionized.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure presents a concept of a bipolar miniature electrostatic ion thruster for maneuvering a small spacecraft. The ionization device in the proposed thruster would be a 0.1-micron-thick dielectric membrane with metal electrodes on both sides. Small conical holes would be micro-machined through the membrane and electrodes. An electric potential of the order of a volt applied between the membrane electrodes would give rise to an electric field of the order of several megavolts per meter in the submicron gap between the electrodes. An electric field of this magnitude would be sufficient to ionize all the molecules that enter the holes.

In a thruster based on this concept, one or more propellant gases would be introduced into such a membrane ionizer. Unlike in larger prior ion thrusters, all of the propellant molecules would be ionized. This thruster would be capable of bipolar operation. There would be two accelerator grids — one located forward and one lo-

cated aft of the membrane ionizer. In one mode of operation, which one could denote the forward mode, positive ions leaving the ionizer on the backside would be accelerated to high momentum by an electric field between the ionizer and an accelerator grid. Electrons leaving the ionizer on the front side would be ejected into free space by a smaller accelerating field. The equality of the ion and electron currents would eliminate the need for an additional electron- or ion-emitting device to keep the spacecraft charge-neutral. In another mode of operation, which could denote the reverse mode, the polarities of the voltages applied to the accelerator grids and to the electrodes of the membrane ionizer would be the reverse of those of the forward mode. The reversal of electric fields would cause the ions and electrons to be ejected in the reverse of their forward-mode directions, thereby giving rise to thrust in the direction opposite that of the forward mode.



A Proposed Miniature Bipolar Electrostatic Ion Thruster would include an ionization membrane. An electric potential between the membrane electrodes would produce an electric field that would generate ions.

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). NPO-21057

## Holographic Plossl Retroreflectors

Lightweight, inexpensive holographic optical elements would be used in place of lenses.

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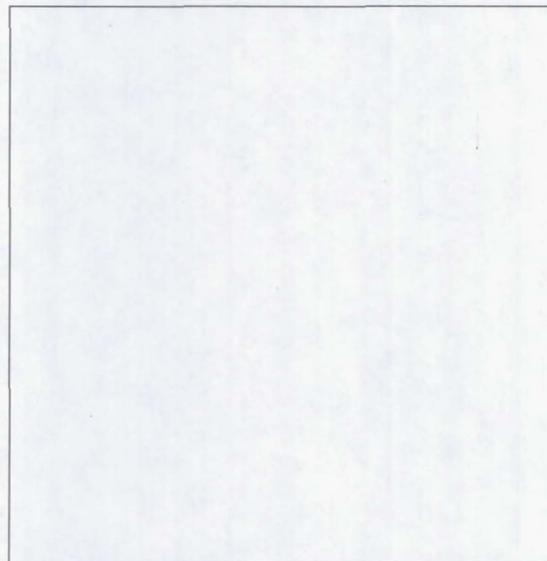
Holographic retroreflectors that function equivalently to Plossl eyepieces have been developed and used in free-space optical communication systems that utilize laser beams. Plossl eyepieces are well known among telescope designers. They have been adopted for use as retroreflectors and as focusing elements (for reception) and collimating elements (for transmission) in optical communication systems. A retroreflector that incorporates a Plossl eyepiece is termed a cat's-eye retroreflector (see figure).

Plossl eyepieces have external pupils and are telecentric. Their telecentricity is what makes them useful as retroreflectors. A Plossl eyepiece is necessarily somewhat complex and expensive because it contains lenses that must be optically corrected to enable operation over a large field of view and a range of visible wavelengths.

In a free-space optical communication system, there is no need for lenses that function over a range of wavelengths because only one wavelength — the laser

wavelength — is used to transmit information. A holographic optical element can readily be designed to perform equivalently to a corrected lens assembly at a single wavelength. If the Plossl eyepiece in a cat's-eye retroreflector were replaced with a holographic optical element, the resulting optical assembly would be simpler and considerably lighter in weight. In addition, in mass production, such holographic optical elements would cost much less than do the corresponding lenses.

This work was done by Eugene Waluschka of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-14472-1



A Cat's-Eye Retroreflector can contain a Plossl eyepiece or, as proposed, could contain a holographic optical element that would act like a Plossl eyepiece at a single wavelength. The holographic element would, in effect, act as an ideal thin lens.