Magnetic Field Would Reduce Electron Backstreaming in Ion Thrusters

Erosion of accelerator grid could also be reduced.

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The imposition of a magnetic field has been proposed as a means of reducing the electron backstreaming problem in ion thrusters.

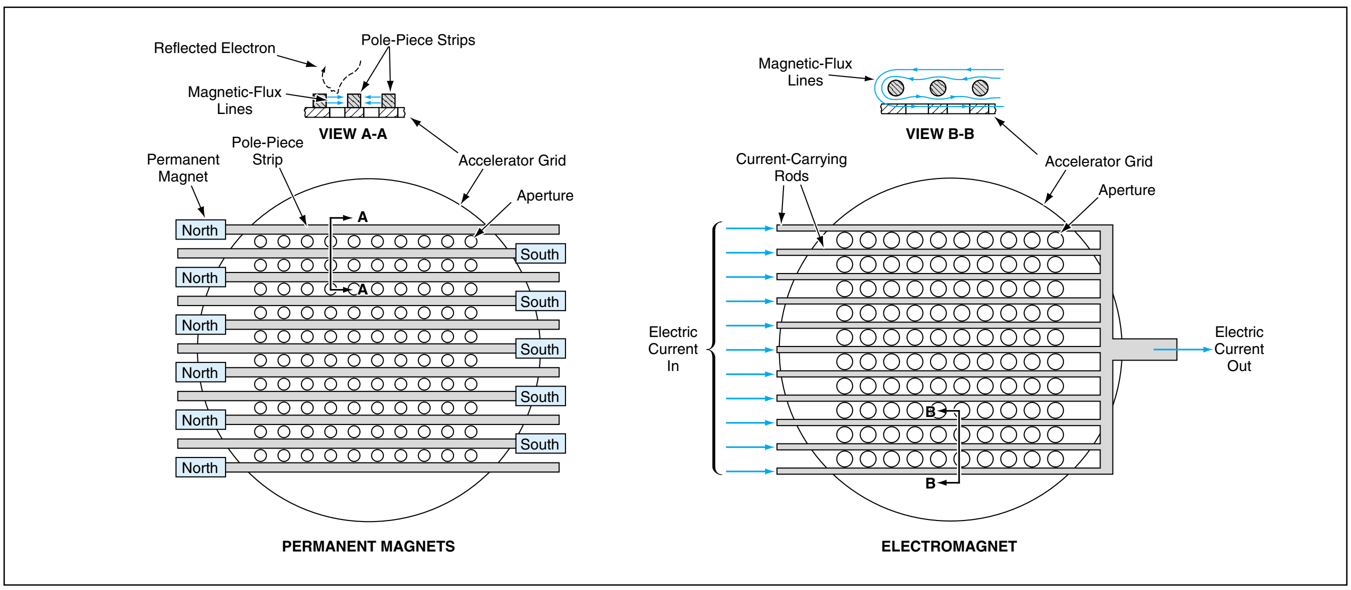
Electron backstreaming refers to the backflow of electrons into the ion thruster. Backstreaming electrons are accelerated by the large potential difference that exists between the ion-thruster acceleration electrodes, which otherwise accelerates positive ions out of the engine to develop thrust. The energetic beam formed by the backstreaming electrons can damage the discharge cathode, as well as other discharge surfaces upstream of the acceleration electrodes. The electron-backstreaming condition occurs when the center potential of the ion accelerator grid is no longer sufficiently negative to prevent electron diffusion back into the ion thruster. This typically occurs over extended periods of operation as accelerator-grid apertures enlarge due to erosion. As a result, ion thrusters are required to operate at increasingly negative accelerator-grid voltages in order to prevent electron backstreaming. These larger negative voltages give rise to higher accelerator-grid erosion rates, which in turn accelerates aperture enlargement. Electron backstreaming due to accelerator-grid-hole enlargement has been identified as a failure mechanism that will limit ion-thruster service lifetime.

The proposed method would make it possible to not only reduce the electron backstreaming current at and below the backstreaming voltage limit, but also reduce the backstreaming voltage limit itself. This reduction in the voltage at which electron backstreaming occurs provides operating margin and thereby reduces the magnitude of negative voltage that must be placed on the accelerator grid. Such a reduction reduces accelerator-grid erosion rates. The basic idea behind the proposed method is to impose a spatially uniform magnetic field downstream of the accelerator electrode that is oriented transverse to the thruster axis. The magnetic field must be sufficiently strong to impede backstreaming electrons, but not so strong as to significantly perturb ion trajectories.

An electromagnet or permanent magnetic circuit can be used to impose the transverse magnetic field downstream of the accelerator-grid electrode. For example, in the case of an accelerator grid containing straight, parallel rows of apertures, one can apply nearly uniform magnetic fields across all the apertures by the use of permanent magnets of alternating polarity connected to pole pieces laid out parallel to the rows, as shown in the left part of the figure. For low-temperature operation, the pole pieces can be replaced with bar magnets of alternating polarity. Alternatively, for the same accelerator grid, one could use an electromagnet in the form of current-carrying rods laid out parallel to the rows, as shown in the right part of the figure.

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-17174.



Either Permanent Magnets or an Electromagnet could be used to apply magnetic fields across the apertures in an ion-accelerator grid. The fields would be made strong enough to reduce backstreaming of electrons without significantly perturbing ion trajectories. In the permanent-magnet case, some external magnetic-circuit components (yokes and opposite poles of permanent magnets) are omitted from the drawing for the sake of simplicity.