

such dampers to suppress traveling-wave vibrations in labyrinth seals. Damping effectiveness depends on many parameters, including, but not limited to, coefficient of friction, mode shape, and frequency and amplitude of vibrational modes. In tests, preloads of the order of 6 to 15 lb (2.72 to 6.8 kg) per spring damper were demonstrated to provide adequate damping levels. Effectiveness of shot damping of vibrations having amplitudes from 20 to 200 times normal ter-

restrial gravitational acceleration (196 to 1,960  $m/s^2$ ) and frequencies up to 12 kHz was demonstrated for shot sizes from 0.032 to 0.062 in. (0.8 to 1.6 mm) at fill levels of from 70 to 95 percent.

*This work was done by Yehia El-Aini, William Mitchell, Lawrence Roberts, Stuart Montgomery, and Gary Davis of Pratt & Whitney Rocketdyne for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov.*

*Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457(f)) to Pratt & Whitney Rocketdyne. Inquiries concerning licenses for its commercial development should be addressed to*

*Pratt & Whitney Rocketdyne  
P.O. Box 109600  
West Palm Beach, FL 33410*

*Refer to MFS-32571-1, volume and number of this NASA Tech Briefs issue, and the page number.*

## 🔧 Two-Arm Flexible Thermal Strap

**This design allows for large elastic displacements in two planes and moderate elasticity in the third plane.**

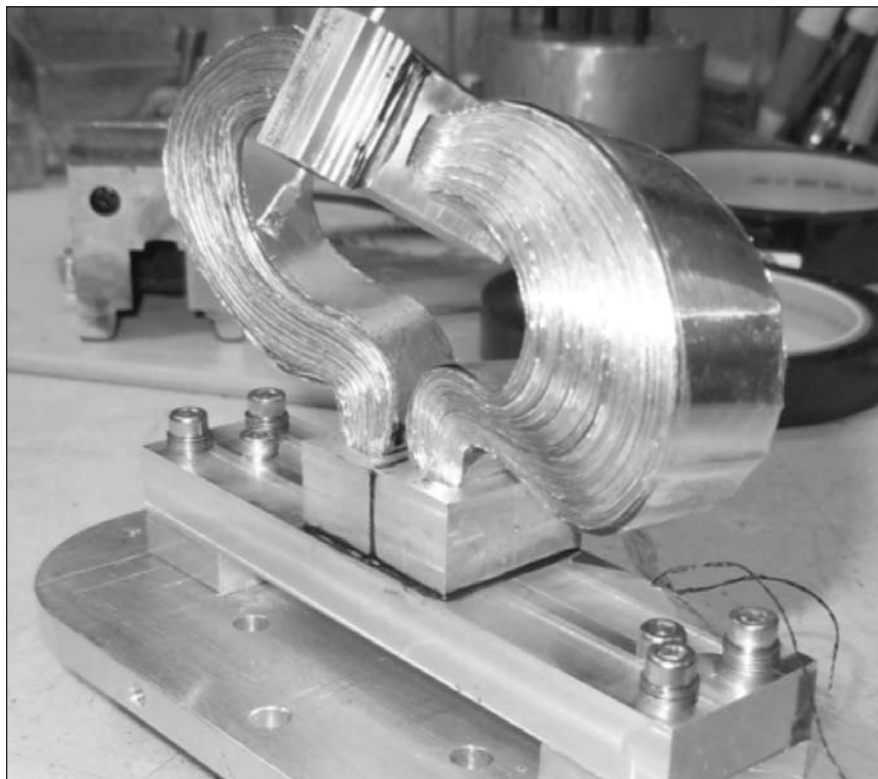
*NASA's Jet Propulsion Laboratory, Pasadena, California*

Airborne and space infrared cameras require highly flexible direct cooling of mechanically-sensitive focal planes. A thermal electric cooler is often used together with a thermal strap as a means to transport the thermal energy removed from the infrared detector. While effective, traditional thermal straps are only truly flexible in one direction. In this scenario, a cooling solution must be highly conductive, lightweight, able to operate within a vacuum, and highly flexible in all axes to accommodate adjustment of the focal plane while transmitting minimal force.

A two-armed thermal strap using three end pieces and a twisted section offers enhanced elastic movement, significantly beyond the motion permitted by existing thermal straps. This design innovation allows for large elastic displacements in two planes and moderate elasticity in the third plane. By contrast, a more conventional strap of the same conductance offers less flexibility and asymmetrical elasticity.

The two-arm configuration reduces the bending moment of inertia for a given conductance by creating the same cross-sectional area for thermal conduction, but with only half the thickness. This reduction in the thickness has a significant effect on the flexibility since there is a cubic relationship between the thickness and the rigidity or bending moment of inertia.

The novelty of the technology lies in the mechanical design and manufacturing of the thermal strap. The enhanced



**Two-Arm Flexible Thermal Strap**

flexibility will facilitate cooling of mechanically sensitive components (example: optical focal planes).

This development is a significant contribution to the thermal cooling of optics. It is known to be especially important in the thermal control of optical focal planes due to their highly sensitive alignment requirements and mechani-

cal sensitivity; however, many other applications exist including the cooling of gimbal-mounted components.

*This work was done by Eugenio Urquiza, Cristal Vasquez, Jose I. Rodriguez, Robert S. Leland, and Byron E. Van Gorp of NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47744*