consequences. Viewers frequently believe an object is beside a robot when it is actually behind it, or think that a small rock is actually a large, hazardous obstacle that must be avoided. Stage addresses both of these problems by immersing viewers in an accurate representation of the operating environment.

*This work was done by Lucy Abramyan, Jeffrey S. Norris, Mark W. Powell, David S. Mittman, and Khawaja S. Shams of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47469*

# Vacuum Camera Cooler

**Cooler maintains proper operating temperature.**

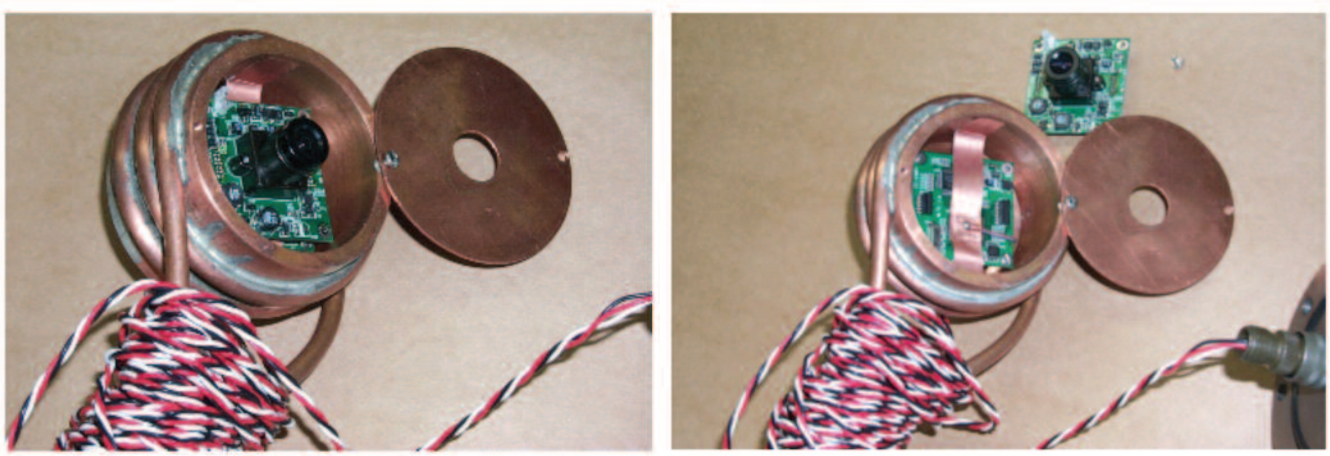
*NASA's Jet Propulsion Laboratory, Pasadena, California*

Acquiring cheap, moving video was impossible in a vacuum environment, due to camera overheating. This overheating is brought on by the lack of cooling media in vacuum. A water-jacketed camera cooler enclosure machined and assembled from copper plate and tube has been developed.

The camera cooler (see figure) is cup-shaped and cooled by circulating water or nitrogen gas through copper tubing. The camera, a store-bought "spy type," is not designed to work in a vacuum. With some modifications the unit can be thermally connected when mounted in the cup portion of the camera cooler. The thermal conductivity is provided by copper tape between parts of the camera and the cooled enclosure.

During initial testing of the demonstration unit, the camera cooler kept the CPU (central processing unit) of this video camera at operating temperature. This development allowed video recording of an in-progress test, within a vacuum environment.

*This work was performed by Geoffrey A. Laugen of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47417*



(a) (b)

**Photos of Vacuum Camera Cooler**: (a) Camera cooler with camera installed and (b) camera cooler with camera partially removed to expose copper tape and thermocouple, which are attached to overheating camera CPU.

# Atomic Oxygen Fluence Monitor

**Applications include the semiconductor industry where atomic oxygen is used to clean and/or remove photoresist from semiconductor surfaces.**

*John H. Glenn Research Center, Cleveland, Ohio*

This innovation enables a means for actively measuring atomic oxygen fluence (accumulated atoms of atomic oxygen per area) that has impinged upon spacecraft surfaces. Telemetered data from the device provides spacecraft designers, researchers, and mission managers with real-time measurement of atomic oxygen fluence, which is useful for prediction of the durability of spacecraft materials and components.

The innovation is a compact fluence measuring device that allows in-space measurement and transmittance of measured atomic oxygen fluence as a function of time based on atomic oxygen erosion yields (the erosion yield of a material is the volume of material that is oxidized per incident oxygen atom) of materials that have been measured in low Earth orbit. It has a linear electrical response to atomic oxygen fluence, and is capable of measuring high atomic oxygen fluences (up to $>10^{22}$ atoms/cm$^2$), which are representative of multi-year low-Earth orbital missions (such as the International Space Station).

The durability or remaining structural lifetime of solar arrays that consist of polymer blankets on which the solar cells are attached can be predicted if one knows the atomic oxygen fluence that the solar array blanket has been exposed to. In addition, numerous organizations that launch space experiments into low-Earth orbit want to know the accumulated atomic oxygen fluence that their materials or components have been exposed to.

The device is based on the erosion yield of pyrolytic graphite. It uses two 12° inclined wedges of graphite that are over a grit-blasted fused silica window covering a photodiode. As the wedges erode, a greater area of solar illumination reaches the photodiode. A reference photodiode is also used that receives unobstructed solar illumination and is oriented in the same direction as the pyrolytic graphite covered photodiode. The short-circuit current from the photodiodes is measured and either sent to an onboard data logger, or transmitted to a receiving station on Earth. By comparison of the short-circuit currents from the fluence-measuring photodiode and the reference photodiode, one can compute the accumulated atomic oxygen fluence arriving in the direction that the fluence monitor is pointing.

The device produces a signal that is linear with atomic oxygen fluence using a material whose atomic oxygen erosion yield has been measured over a period of several years in low-Earth orbit.

*This work was done by Bruce A. Banks of the 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, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18639-1.*