

elasticity, so that between steps, the gripper returns to a default position that is roughly parallel to the wall.

In order to give the ankle freedom to rotate about all three degrees of freedom, the gripper is mounted on a series of gimbals similar to those found on a gyroscope. The rotation of the gimbals about radial directions is limited by springs, which bring the gripper back to a default position in between steps of the robot. These springs have a relatively low spring-constant so as not to induce large torques that may upset the gripper's hold on the rock. Additionally, microspine engagement is achieved

through a motor that turns a spool and pulls on cables connected to the spine arrays. A linear actuator that pulls the microspines up and away from the rock face provides disengagement. Previous microspine robots have been limited by their feet, which only sustain forces in one direction and only work on globally smooth surfaces like brick walls and concrete. The omnidirectional anchors extend the potential of legged robots using microspines to natural rock, and would allow gripping at any orientation including inverted or in zero gravity.

This work was done by Aaron Parness, Matthew A. Frost, and Nitish Thatte of Cal-

tech 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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Refer to NPO-48315 volume and number of this NASA Tech Briefs issue, and the page number.

Wind, Wave, and Tidal Energy Without Power Conditioning

NASA's Jet Propulsion Laboratory, Pasadena, California

Most present wind, wave, and tidal energy systems require expensive power conditioning systems that reduce overall efficiency. This new design eliminates power conditioning all, or nearly all, of the time.

Wind, wave, and tidal energy systems can transmit their energy to pumps that send high-pressure fluid to a central power production area. The central power production area can consist of a series of hydraulic generators. The hy-

draulic generators can be variable displacement generators such that the RPM, and thus the voltage, remains constant, eliminating the need for further power conditioning.

A series of wind blades is attached to a series of radial piston pumps, which pump fluid to a series of axial piston motors attached to generators. As the wind is reduced, the amount of energy is reduced, and the number of active hydraulic generators can be reduced to

maintain a nearly constant RPM. If the axial piston motors have variable displacement, an exact RPM can be maintained for all, or nearly all, wind speeds. Analyses have been performed that show over 20% performance improvements with this technique over conventional wind turbines.

This work was done by Jack A. Jones of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48620

An Active Heater Control Concept to Meet IXO Type Mirror Module Thermal-Structural Distortion Requirement

This innovation offers a number of advantages in terms of reduced mass, problem of routing, and the risk of x-ray attenuation.

Goddard Space Flight Center, Greenbelt, Maryland

Flight mirror assemblies (FMAs) of large telescopes, such as the International X-ray Observatory (IXO), have very stringent thermal-structural distortion requirements. The spatial temperature gradient requirement within a FMA could be as small as 0.05 °C. Conventionally, heaters and thermistors are attached to the stray light baffle (SLB), and centralized heater controllers (i.e., heater controller boards located in a large electronics box) are used. Due to the large number of heater harnesses, accommodating and routing them is extremely difficult. The total harness length/mass is

very large. This innovation uses a thermally conductive pre-collimator to accommodate heaters and a distributed heater controller approach. It minimizes the harness length and mass, and reduces the problem of routing and accommodating them.

Heaters and thermistors are attached to a short (4.67 cm) aluminum portion of the pre-collimator, which is thermally coupled to the SLB. Heaters, which have a very small heater power density, and thermistors are attached to the exterior of all the mirror module walls. The major portion (23.4 cm) of the pre-collimator for the middle and outer modules

is made of thin, non-conductive material. It minimizes the view factors from the FMA and heated portion of the pre-collimator to space. It also minimizes heat conduction from one end of the FMA to the other. Small and multi-channel heater controllers, which have adjustable set points and internal redundancy, are used. They are mounted to the mechanical support structure members adjacent to each module.

The IXO FMA, which is 3.3 m in diameter, is an example of a large telescope. If the heater controller boards are centralized, routing and accommodating heater harnesses is extremely dif-