



## Mechanics/Machinery

### Pneumatic Haptic Interfaces

**Arrays of balloonlike actuators would provide tactile feedback from robot hands.**

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

Haptic interfaces in the form of arrays of balloonlike pneumatic actuators are being developed to provide tactile feedback from (1) remote-manipulator hands, tools on the tips of robot arms, and other, similar devices to (2) the hands of human operators. Like other haptic interfaces, these have numerous potential applications in situations in which there are requirements to manipulate remote, very small, and possibly fragile objects with great dexterity and sensitivity. Haptic interfaces are especially valuable as components of robotic implementations of laparoscopic surgical tools, which are used to remotely cut, pull, and move various types of tissue, the degree of softness and hardness of which is difficult or impossible to judge in the absence of tactile feedback.

The figure presents two views of an experimental prototype array that included (1) a molded block of one type of silicone rubber containing holes that define the array of pneumatic actuators and (2) a thin sheet, made of more flexible silicone rubber, bonded to the surface of the block so as to cover the holes. To demonstrate pneumatic actuation, a syringe needle was poked through the block into one of the holes and the syringe plunger was used to force air into the hole, thereby causing the portion of the sheet covering the hole to push outward. In addition, automatic inflation and deflation of the balloon array was demonstrated by using an electronic pressure regulator connected to pressured gas reservoir.



A Syringe Is Used to pump air into one of the holes in the block, causing the portion of the sheet covering that hole to protrude to provide a tactile sensation.

After further development, the spatial resolution of the array in a typical application could be expected to be much finer than that shown in the figure — fine enough to enable the device to mimic the shape and texture of an object in contact with a robot hand. In addition, it would be possible to pressurize each hole to the same or a different degree to provide a desired tactile sensation. For example, the pressure in one or more holes could be adjusted to convey a sensation of pressure or force of contact and/or a sense of the hardness of an object in contact with a robot hand. Alternatively or in addition, the pressure in each hole could be varied, independently of the pressures in other holes, as part of a pattern of pressures that could convey a sense of the texture and/or motion of an object.

*This work was done by Sam Y. Bae, Victor White, and Harish Manohara of Caltech 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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### Device Acquires and Retains Rock or Ice Samples

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The Rock Baller is a sample acquisition tool that improves sample retention. The basic elements of the Rock Baller are the tool rotation axis, the hub, the two jaws, and the cutting blades, which are located on each of the jaws. The entire device rotates about the tool rotation axis, which is aligned parallel to the nom-

inal normal direction of the parent rock surface. Both jaws also rotate about the jaw axis, which is perpendicular to the tool rotation axis, at a rate much slower than the rotation about the tool rotation axis. This movement gradually closes the jaws into a nearly continuous hemispherical shell that encloses the sample as it is

cut from the parent rock. When required the jaws are opened to release the sample. The hemispherical cutting method eliminates the sample retention problems associated with existing sample acquisition methods that employ conventional cylindrical cutting.

The resulting samples are hemispher-