❀ Ultrasonically Actuated Tools for Abrading Rock Surfaces

These offer the same advantages as do ultrasonically actuated drilling and coring tools.

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An ultrasonic rock-abrasion tool (URAT) was developed using the same principle of ultrasonic/sonic actuation as that of the tools described in two prior *NASA Tech Briefs* articles: "Ultrasonic/Sonic Drill/Corers With Integrated Sensors (NPO-20856), Vol. 25, No. 1 (January 2001), page 38 and "Ultrasonic/Sonic Mechanisms for Drilling and Coring" (NPO-30291), Vol. 27, No. 9 (September 2003), page 65. Hence, like those tools, the URAT offers the same advantages of low power demand, mechanical simplicity, compactness, and ability to function with very small axial loading (very small contact force between tool and rock).

Like a tool described in the second of the cited previous articles, a URAT includes (1) a drive mechanism that comprises a piezoelectric ultrasonic actuator, an amplification horn, and a mass that is free to move axially over a limited range and (2) an abrasion tool bit. A URAT tool bit is a disk that has been machined or otherwise formed to have a large number of teeth and an overall shape chosen to impart the desired shape (which could be flat or curved) to the rock surface to be abraded. In operation, the disk and thus the teeth are vibrated in contact with the rock surface. The concentrated stresses at the tips of the impinging teeth repeatedly induce microfractures and thereby abrade the rock. The motion of the tool induces an ultrasonic transport effect that displaces the cuttings from the abraded area.

The figure shows a prototype URAT. A piezoelectric-stack/horn actuator is housed
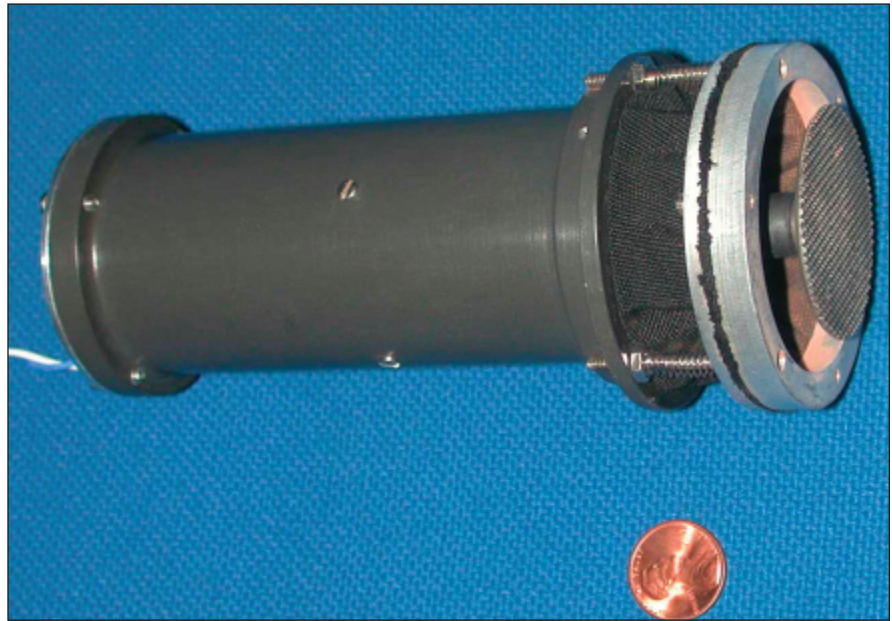
This **Prototype URAT** is one of several that have been constructed thus far. It has a total mass of 0.4 kg, a length of 5.65 in. (14.4 cm), and a maximum diameter of 2.5 in. (6.35 cm). The textured disk at the right end is the tool bit.

in a cylindrical container. The movement of the actuator and bit with respect to the housing is aided by use of mechanical sliders. A set of springs accommodates the motion of the actuator and bit into or out of the housing through an axial range between 5 and 7 mm. The springs impose an approximately constant force of contact between the tool bit and the rock to be abraded. A dust shield surrounds the bit, serving as a barrier to reduce the migration of rock debris to sensitive instrumentation or mechanisms in the vicinity. A bushing at the tool-bit end of the housing reduces the flow of dust into the actuator and retains the bit when no axial load is applied.

❀ Active Struts With Variable Spring Stiffness and Damping

These struts would act as linear actuators and controllable shock absorbers.

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Controllable active struts that would function as linear actuators with variable spring stiffness and damping have been proposed as components of advanced suspension systems of future wheeled

ground vehicles. The contemplated advanced suspension systems would include computer-based control subsystems that would continually adjust the actuator responses to obtain optimal

combinations of safety and comfort under operating conditions ranging from low speeds over smooth roads to high speeds over rough, unpaved ground. The proposed struts and suspen-

sion systems were originally intended for use in military vehicles, but there could also be a broad commercial market for them in trucks and sport utility vehicles.

A strut according to the proposal (see figure) would include an air spring in the form of a plunger sliding longitudinally in a pneumatic chamber. Compressed air would be supplied to the pneumatic chamber, from an external pump and accumulator, via a pneumatic hose and a high-speed valve. The chamber would be instrumented with (1) an electronic extensometer to monitor the axial displacement of the plunger and (2) an electronic air-pressure sensor. Notwithstanding the extensometer, the air spring would be used primarily to regulate the spring stiffness, rather than the length, of the strut. The diameter of the plunger would be small, so that only a small amount of compressed air would have to be pumped in or allowed to flow out to change the spring stiffness by a given amount. Because of the small amount of air needed and because the air spring would operate at moderate to high pressure, the required amount of air could be made to flow into or out of it rapidly and, hence, the spring stiffness could be changed rapidly on command.

The pneumatic chamber would also serve as a plunger that would slide longitudinally in a hydraulic chamber. Like the pneumatic chamber, the hydraulic chamber would be equipped with a pressure sensor, extensometer, and high-speed valve. However, instead of compressed air, hydraulic fluid would be supplied to this chamber from an external hydraulic pump, accumulator, and reservoir. The hydraulic chamber would be used primarily to adjust the length of the strut; secondarily, it could be used as a very stiff spring in the event of a malfunction of the air spring. The hydraulic fluid would be pumped in to extend the strut. Retraction would be effected by actuating the valve to allow the load on the strut to push hydraulic fluid back to the reservoir. Like the pneumatic chamber,
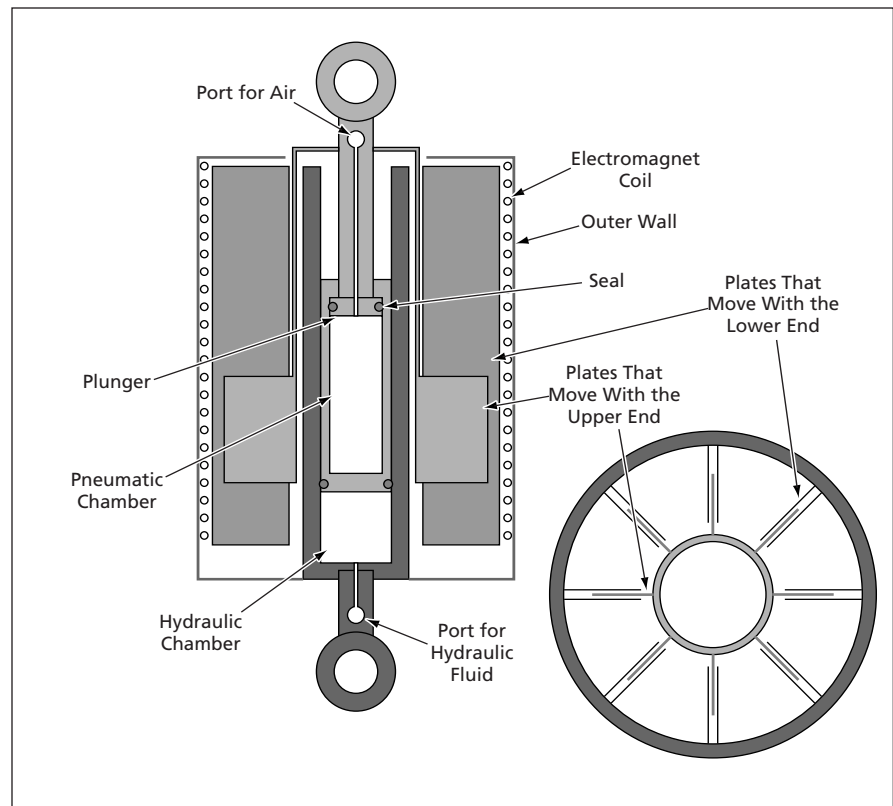
A **Strut Assembly** according to the proposal would contain a pneumatic actuator, a hydraulic actuator, and a magnetorheological damping actuator.

the hydraulic chamber would have a small volume and would be operated at high pressure; hence, the length of the strut could be adjusted within a short response time.

A device denoted an actuator-restraining device (ARD) would provide controllable damping. The ARD would include (1) a set of plates, oriented in radial-axial planes, that would move with one end of the strut and (2) a set of pairs of plates, each pair parallel and close to one of the first-mentioned plates, that would move with the other end of the strut. The narrow spaces between the plates would be filled with a magnetorheological fluid, the effective viscosity of which would be controlled by the current in an electromagnet coil. In the absence of current, the plates would slide almost freely, so

that any damping would be that attributable to friction damping in the air spring and the hydraulic actuator. In general, the amount of damping could be increased or decreased to almost any desired level by increasing or decreasing the current applied to the coil. By applying sufficient current, one could even obtain a damping or restraining force greater than the weight of the vehicle. The response time of the ARD would be an order of magnitude shorter than the response times of the pneumatic and hydraulic actuators.