

Single Piezo-Actuator Rotary-Hammering Drill

The minimal number of parts in this drill increases reliability and eliminates potential failure points.

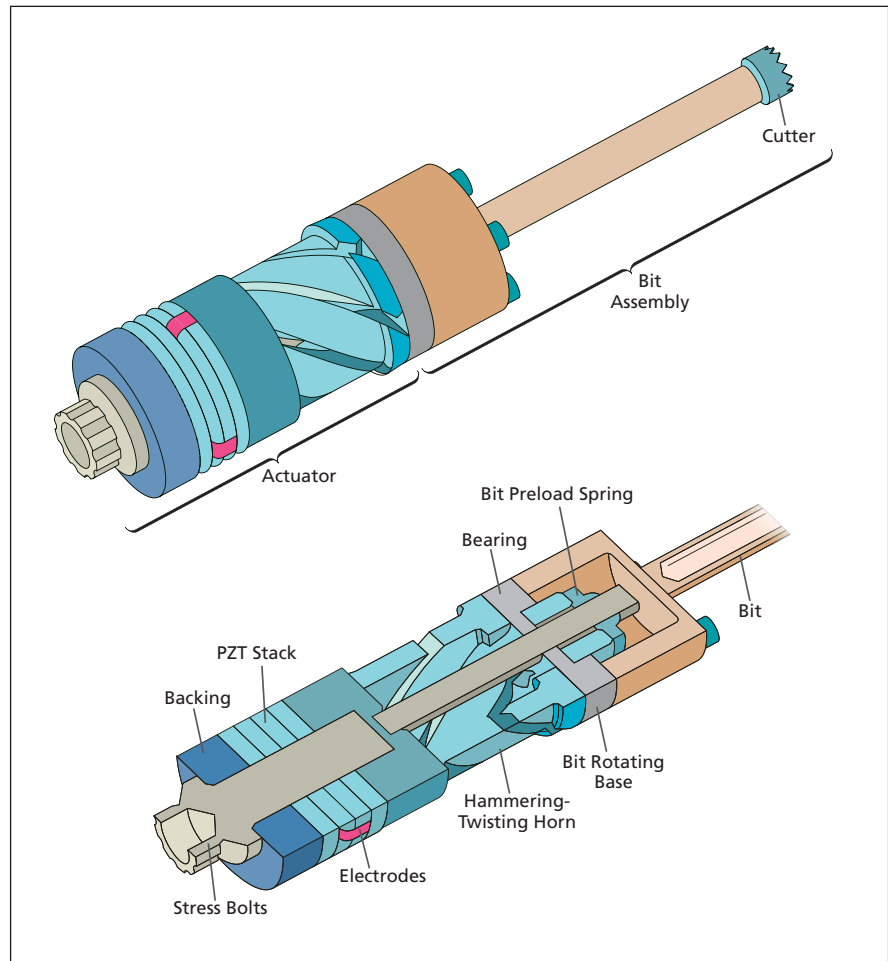
NASA's Jet Propulsion Laboratory, Pasadena, California

This innovation comprises a compact drill that uses low-axial preload, via vibrations, that fractures the rock under the bit kerf, and rotates the bit to remove the powdered cuttings while augmenting the rock fracture via shear forces. The vibrations "fluidize" the powdered cuttings inside the flutes around the bit, reducing the friction with the auger surface. These combined actions reduce the consumed power and the heating of the drilled medium, helping to preserve the pristine content of the produced samples.

The drill consists of an actuator that simultaneously impacts and rotates the bit by applying force and torque via a single piezoelectric stack actuator without the need for a gearbox or lever mechanism. This reduces the development/fabrication cost and complexity.

The piezoelectric actuator impacts the surface and generates shear forces, fragmenting the drilled medium directly under the bit kerf by exceeding the tensile and/or shear strength of the struck surface. The percussive impact action of the actuator leads to penetration of the medium by producing a zone of finely crushed rock directly underneath the struck location. This fracturing process is highly enhanced by the shear forces from the rotation and twisting action. To remove the formed cuttings, the bit is constructed with an auger on its internal or external surface. One of the problems with pure hammering is that, as the teeth become embedded in the sample, the drilling efficiency drops unless the teeth are moved away from the specific footprint location. By rotating the teeth, they are moved to areas that were not fragmented, and thus the rock fracturing is enhanced via shear forces. The shear motion creates ripping or chiseling action to produce larger fragments to increase the drilling efficiency, and to reduce the required power.

The actuator of the drill consists of a piezoelectric stack that vibrates the horn. The stack is compressed by a bolt between the backing and the horn in order to prevent it from being subjected to tensile stress that will cause it to fail. The



Cross-section and solid isometric views of the **Single Piezo-Actuator Rotary-Hammering Drill**. The bit is interfaced with the horn via a bit rotating base and is bolted to the horn via a bearing and preload spring.

backing is intended to transfer the generated mechanical vibrations towards the horn. In order to cause rotation, the horn is configured asymmetrically with helical segments and, upon impacting the bit, it introduces longitudinal along the axis of the actuator and tangential force causing twisting action that rotates the bit. The longitudinal component of the vibrations of the stack introduces percussion impulses between the bit and the rock to fracture it when the ultimate strain is exceeded under the bit.

This work was done by Stewart Sherrit, Xiqi Bao, Mircea Badescu, and Yoseph Bar-Cohen 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:

Innovative Technology Assets Management

JPL

Mail Stop 202-233

4800 Oak Grove Drive

Pasadena, CA 91109-8099

E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-47216, volume and number of this NASA Tech Briefs issue, and the page number.