Foldable Instrumented Bits for Ultrasonic/Sonic Penetrators

These bits are stowed compactly, then extended to full length when needed.

NASA’s Jet Propulsion Laboratory, Pasadena, California

Long tool bits are undergoing development that can be stowed compactly until used as rock- or ground-penetrating probes actuated by ultrasonic/sonic mechanisms. These bits are designed to be folded or rolled into compact form for transport to exploration sites, where they are to be connected to their ultrasonic/sonic actuation mechanisms and unfolded or unrolled to their full lengths for penetrating ground or rock to relatively large depths. These bits can be designed to acquire rock or soil samples and/or to be equipped with sensors for measuring properties of rock or soil in situ. These bits can also be designed to be withdrawn from the ground, restowed, and transported for reuse at different exploration sites.

Apparatuses based on the concept of a probe actuated by an ultrasonic/sonic mechanism have been described in numerous prior NASA Tech Briefs articles, the most recent and relevant being “Ultrasonic/Sonic Impacting Penetrators” (NPO-41666) NASA Tech Briefs, Vol. 32, No. 4 (April 2008), page 58. All of those apparatuses are variations on the basic theme of the earliest ones, denoted ultrasonic/sonic drill corers (USDCs). To recapitulate: An apparatus of this type includes a lightweight, low-power, piezoelectrically driven actuator in which ultrasonic and sonic vibrations are generated and coupled to a tool bit. The combination of ultrasonic and sonic vibrations gives rise to a hammering action (and a resulting chiseling action at the tip of the tool bit) that is more effective for drilling than is the microhammering action of ultrasonic vibrations alone. The hammering and chiseling actions are so effective that the size of the axial force needed to make the tool bit advance into soil, rock, or another mate-

Hinged Lower and Upper Segments of a tool bit and supporting structure are unfolded at the hinges and locked in axial alignment. The resulting assembly is then positioned with the lower end of the tool bit in contact with the ground. The lower views show a conceptual sequence for deployment from an exploratory robotic vehicle, but this sequence is also typical of deployment in other settings.
Compact Rare Earth Emitter Hollow Cathode
This rare earth insert for ion and Hall thrusters has longer life and resistance to poisoning.

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A compact, high-current, hollow cathode utilizing a lanthanum hexaboride (LaB$_6$) thermionic electron emitter has been developed for use with high-power Hall thrusters and ion thrusters. LaB$_6$ cathodes are being investigated due to their long life, high current capabilities, and less stringent xenon purity and handling requirements compared to conventional barium oxide (BaO) dispenser cathodes. The new cathode features a much smaller diameter than previously developed versions that permit it to be mounted on axis of a Hall thruster (“internally mounted”), as opposed to the conventional side-mount position external to the outer magnetic circuit (“externally mounted”). The cathode has also been reconfigured to be capable of surviving vibrational loads during launch and is designed to solve the significant heater and materials compatibility problems associated with the use of this emitter material. This has been accomplished in a compact design with the capability of high-emission current (10 to 60 A). The compact, high-current design has a keeper diameter that allows the cathode to be mounted on the centerline of a 6-kW Hall thruster, inside the iron core of the inner electromagnetic coil.

Although designed for electric propulsion thrusters in spacecraft station-keeping, orbit transfer, and interplanetary applications, the LaB$_6$ cathodes are applicable to the plasma processing industry in applications such as optical coatings and semiconductor processing where reactive gases are used. Where current electrical propulsion thrusters with BaO emitters have limited...

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The diagram shows the schematic of the Hollow Cathode with external gas feeds either directly into the cathode plume or into the cathode keeper gap, both of which feed gas into the plasma exterior to the insert region. The cathode features a lanthanum hexaboride (LaB$_6$) thermionic electron emitter, with external gas feeds either directly into the cathode plume or into the cathode keeper gap, both of which feed gas into the plasma exterior to the insert region.