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TECHNICAL NOTE

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Borehole Monitoring with Impulse Acoustic Sensors

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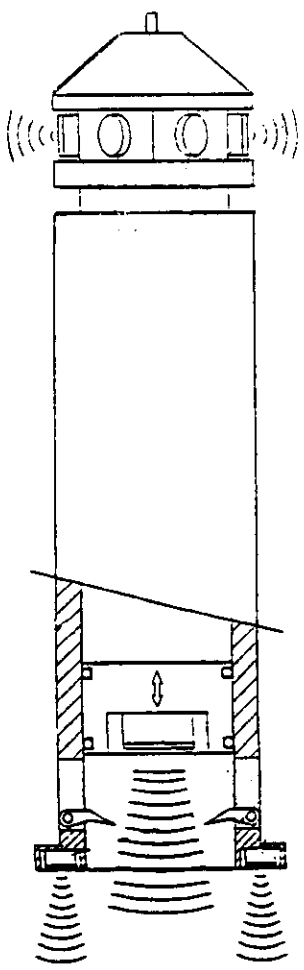
Introduction

To successfully drill deep boreholes in glaciers, it is necessary to precisely monitor the following parameters:

- borehole geometry (diameter and profile, inclination)
- position of drill instrument in the borehole
- position of the ice core in the core barrel
- quality and conditions of the borehole fluid

Operational information regarding these parameters allows increased efficiency of the drilling process and decreases losses of the ice core.



Acoustic Impulse Sounding

High frequency, acoustic impulse sounding for measuring distance in liquids can be used for borehole monitoring. The following are advantages of acoustic sounding for distance measurements:

- high distance and angle resolution (up to 0.1 mm and 1°)
- large range of measuring distance (from millimeters to meters)
- compact sensors
- compact and simple electronics can be mounted on the drill
- acoustic sensors can be operated in high pressure and low temperature conditions
- acoustic sensors are solid piezoelectric crystals, covered by rubber, plastic ceramics or metal

Optical methods, as well as a TV camera or laser sensors, can be used for glacier borehole monitoring. However, industrial types of such equipment are expensive and need modification for mounting on a drill. The existing ultrasonic acoustic equipment is also expensive and cannot be used without modification.

Ultrasonic equipment is used extensively in industry for detecting defects in metal, plastic, etc. Also, it is widely used for marine investigations.

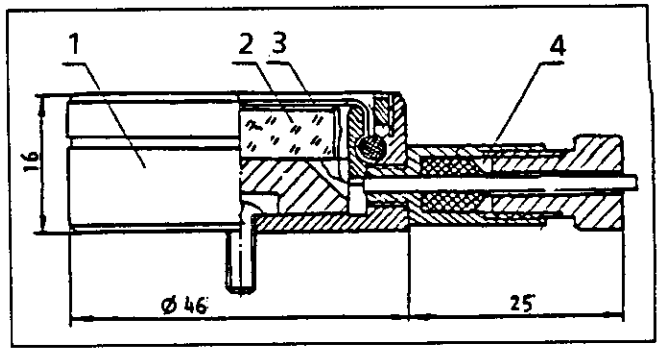


Figure 1. Acoustic antenna (sensor); dimensions in millimeters.

1-Body *3-Rubber cover*
2-Piezoelectric crystal *4-Cable termination*

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Ultrasonic equipment has been used by V. Zagorodnov for observing the melting-freezing processes under the Ross Ice Shelf, Antarctica (J-9 drill camp) in 1978-79. By using a 0.6 MHz (Figure 1) sensor, a 95-cm diameter borehole was measured with 0.2-mm resolution. The maximum distance measured with this sensor under the Ross Ice Shelf (thickness 420 m) was 7 m.

Conclusions

Schematics depicting drills with ultrasonic sensors are shown in Figures 2 and 3. Six acoustic sensors on the upper part of any type of drill allow measurement of the borehole diameter, with their profile and the position of the drill relative to the borehole center. This offers the opportunity to observe the borehole closure and hole deformation. It also can be used for selecting drill speed during penetration.

Measuring the distance with the front sensors allows a gentler touch of the kerf by the ice core drill, and it also allows observation of the position of the ice core in the core barrel.

During the drilling process, the same sensors can be used for monitoring the quality of the borehole liquids. Scattering acoustical waves on the dispersed solid particles (ice chips, ice slush, sand or rock fragments) will cause output signal attenuation.

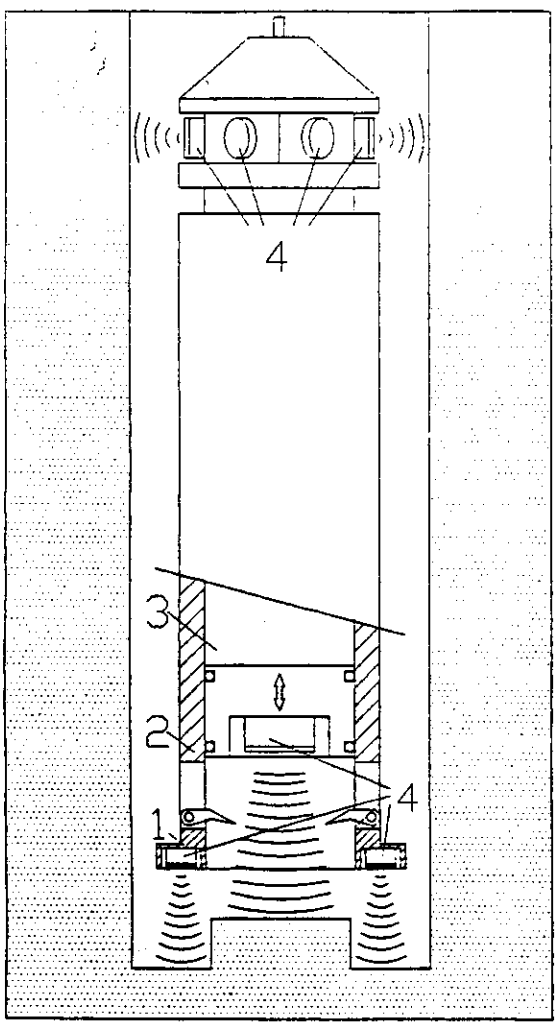

Figure 2. Ice core drill with acoustic sensors.

1-Drilling head *3-Piston*
2-Core barrel *4-Acoustic sensors*

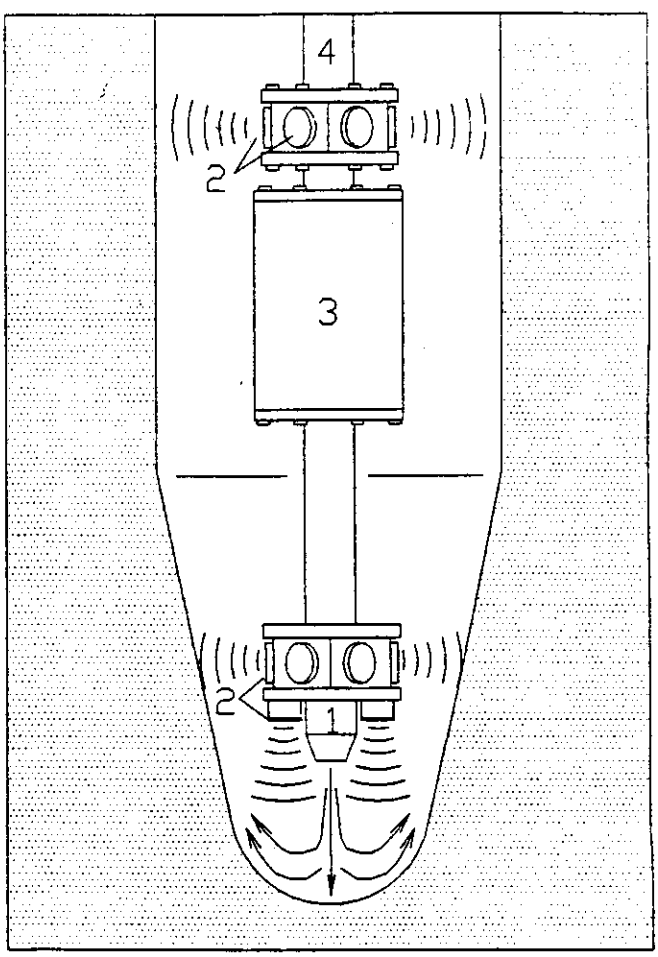

Figure 3. Hot water drill with acoustic sensors.

1-Nozzle *3-Instrumentation package*
2-Acoustic sensors *4-Hose and cable line*