

Drilling Large Diameter Boreholes in Snow and Firn

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Introduction

The study of snow-firn sequences of glaciers by pit excavation takes a considerable amount of time. However, rapid penetration of snow-firn layers can be accomplished using large-diameter drills. A prototype of such a drill was designed and tested at Vostok Station in Antarctica by researchers V. V. Toskin, L. N. Manevsky and A. I. Tolstoy from the Ice Technics and Thermodrilling Laboratory of the Arctic Antarctic Research Institute. A 0.4-m diameter borehole, 6.5 m deep was drilled with a vibratory drill.

Vibratory Drill

The vibratory drill (Figure 1) includes a core barrel with a hardened steel tip and a 1.5-kw electrical motor-vibrator. The vibrator provides vertical vibration to the core barrel with 50 Hz frequency. The penetration of the drill into the glacier occurs as the tip displaces snow or firn. Displacement of some of the material by the hardened steel tip causes a compacted layer on the surface of the core which increases friction on the inside of the core barrel causing the core to stay inside the barrel. The vibration helps the core stick in the tube and makes the extraction process easier. An electric winch and cable are used to raise and lower the drill in and out of the borehole.

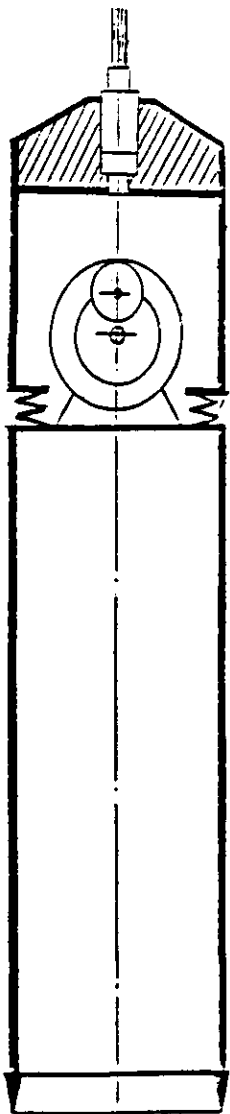
Field Tests

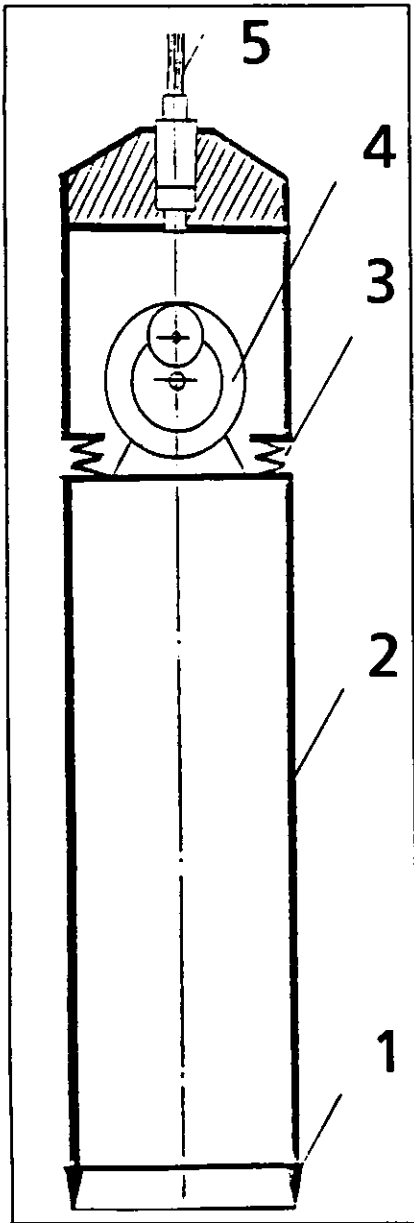
Field tests show a drill penetration rate of 6 to 8 m/min in a snow-firn layer at -50°C. One complete drilling cycle requires 1 to 5 min and includes:

- lowering the drill
- penetrating the core barrel into the firn
- breaking the core
- extracting the core

The depth of the borehole is increased 1.2 m with each drilling cycle. Although the vibrator should be operated during core breaks and extraction of the core from the borehole, it does cause destruction of one-third of the top and the bottom of the core.

A winch capable of producing a line tensile force of 3000 N with a variable line speed for both penetration and hoisting is necessary to avoid destruction of top and bottom sections of the core. Power requirements for 0.8 to 1.0-m diameter boreholes in snow and firn should require from 5 to 8 kw. Weight of the vibratory drill should be about 300 kg. The total weight of the equipment for large-diameter borehole drilling is estimated to be from 600 to 800 kg.





Drill Specifications

- Outer diameter 0.4 m
- Snow or firn core diameter 0.38 m
- Drill/Core length 2.2/1.2 m
- Power consumption 1.5 kw
- Vibrator frequency 50 Hz
- Drilling rate 6-8 m/min
- Penetration rate 12-20 m/h
- Weight 80 kg

Figure 1. Schematic of vibratory drill

- 1 - hard steel tip
- 2 - core barrel
- 3 - shock absorber
- 4 - electrical motor-vibrator
- 5 - armored cable