INSTRUMENTS AND METHODS

A STEAM-OPERATED ICE DRILL FOR THE INSTALLATION OF ABLATION STAKES ON GLACIERS

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Abstract. An easily portable thermal ice drill was designed and constructed, with water vapour being used for melting the ice. A bore hole, 8 m. deep, can be drilled within about 30 min., depending on the ice properties. The energy for boiling the water is supplied by butane cartridges similar to those used for camping purposes. One cartridge lasts for drilling about three holes 8 m. deep. The weight of the whole equipment is 12·5 kg.

Résumé. *Equipement de forage thermique pour implantation de balises d'ablation.* Un léger équipement de forage thermique a été construit qui utilise la vapeur d'eau pour fondre la glace. Selon les conditions de la glace on peut effectuer des forages jusqu'à une profondeur de 8 mètres en 30 minutes environ. L'énergie nécessaire pour produire la vapeur est fournie par un brûleur butane genre camping. Une cartouche de butane suffit pour forer 3 trous, chacun d'une profondeur de 8 mètres. L'ensemble de l'équipement pèse 12,5 kg.

Zusammenfassung. *Ein thermischer Eisbohrer zum Einsetzen von Ablationspegeln auf Gletschern.* Ein leichter thermischer Eisbohrer wurde konstruiert, bei dem Wasserdampf zum Schmelzen des Eises verwendet wird. Ein Bohrloch von 8 m Tiefe wird je nach Eisverhältnissen in etwa 30 Minuten gebohrt. Die Energie zur Erzeugung des Dampfes wird von einem Butanbrenner geliefert, wie er für Camping verwendet wird. Eine Butanpatrone reicht zum Bohren von drei Löchern von je 8 m Tiefe. Das Gewicht der ganzen Ausrüstung beträgt 12,5 kg.

In the programme of mass balance studies on the Hintereisferner, Ötztal Alps (Hoinkes and Rudolph, 1962), ablation stakes of 20 mm. diameter and 4 m. length are placed to determine ablation values. Hand-operated drills suitable for drilling holes to a depth of 4 m. are used for the installation of the stakes. As the ablation values on the Hintereisferner may reach as much as 7 m./yr., it is often necessary to re-drill the bore holes during the ablation period. For these reasons a method was sought which makes it possible to drill holes of 20 mm. diameter as deep as 8 m.

Working Principles

The new thermal ice drill uses water vapour for melting the ice in the bore hole. 1 kg. of water vapour provides 639 kcal. of energy with which 8 kg. of ice can be melted. The water is vaporized in a boiler and the steam is conducted through a hose into the drill tip where it condenses and melts the ice. No pump is needed to pump hot water into the drill tip as in other drilling equipment (Kasser, 1960). It is sufficient to conduct the steam into the drill tip; the condensed water together with the melt water flows out of the bore hole along the drill hose.

Design and Construction

A 3-l. boiler was used for boiling the water to produce steam, a wind shield serving simultaneously as support. The steam pressure was checked by a pressure gauge mounted on top of the boiler. Heating was done with a burner fueled by butane which was supplied by cartridges as used for camping purposes. A rubber hose, 21 mm. outer diameter, 13 mm. inner diameter and 8·5 m. long, was connected to the vessel. In order to minimize the heat flow through the hose material it is essential to insert a second hose into the outer one. The air gap between the inner and outer hoses proved to be a sufficient heat insulation. At the end of the hose, a 13 × 11 mm. guide tube (2 m. long) was mounted inside the outer hose. This serves to keep the bore hole straight. The drill tip, which was soldered to the guide tube, consisted of a brass rod, 30 cm. long and 21 mm. outer diameter, through which an 8 mm.

hole was drilled. The inner hose was put through this hole and fastened at the end of the drill tip where a nozzle was screwed in. The nozzle was made interchangeable so that the optimum diameter could be determined. An excess pressure of about 0·6 kg./cm.^{2} is required to drive the steam through the hose. The weight of the boiler including wind shield, bottom plate and burner is 8·5 kg., and the weight of the hose and the drill tip is 4 kg. A handle was mounted for carrying the equipment easily from one bore hole to another.

Field Tests

A test study on the Hintereisferner showed the drill was well suited for drilling holes 8 m. deep into the ice. On the average an 8 m. hole was drilled within 30 min. The optimum nozzle diameter proved to be 2·5 mm. for maximum drilling speed. One butane cartridge lasted for about 110 min., which is sufficient to drill three 8 m. deep holes, including the time needed for boiling the water. The heat losses occurring between burner and vessel are about 50 per cent. The remaining energy, which is available in the form of steam, is divided as follows:

about 10 per cent loss through the hose wall outside the bore hole;
about 46 per cent loss through the hose wall inside the bore hole;
about 44 per cent energy available for drilling the hole with a diameter of 21 mm.

Along the guide tube the profile of the bore hole is practically true to size. The hole then widens owing to the heat flowing through the hose wall, and reaches approximately 35 mm. diameter at the glacier surface when an 8 m. hole is drilled. It is expected that the heat losses inside the bore hole can be reduced by using a special inner hose with high heat insulation properties.

The speed of drilling depends on the ice conditions, mainly on the contamination, e.g. sand or sludge which may accumulate in front of the drill tip. The drilling speed proved to be nearly constant down to 8 m.; therefore it may be expected that holes deeper than 8 m. can also be drilled with this equipment.

The experiments with the test model suggest the following improvements which will be taken into consideration for the final design:

1. Heat-resistant inner hose with better heat insulation properties.
2. Increase in the heating power by using two butane burners.
3. Installation of a water-level indicator.
4. Stop valve for maintaining the steam pressure when the equipment is carried from one bore hole to another.
5. Installation of a safety valve.
6. Increase in boiler capacity to about 5 l.

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REFERENCES

Hoinkes, H. C., *and* Rudolph, R. 1962. Mass balance studies on the Hintereisferner, Ötztal Alps, 1952–1961. *Journal of Glaciology*, Vol. 4, No. 33, p. 266–80.

Kasser, P. 1960. Ein leichter thermischer Eisbohrer als Hilfsgerät zur Installation von Ablationsstangen auf Gletschern. *Geofisica Pura e Applicata*, Vol. 45, No. 1, p. 97–114. [Reviewed by R. L. Shreve in *Journal of Glaciology*, Vol. 4, No. 32, 1962, p. 234–35.]