EQUIPMENT AND TECHNOLOGY FOR DRILLING IN TEMPERATE GLACIERS

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ABSTRACT

Three drill units suitable for drilling in temperate ice are described. They are an electro-thermal corer, an electro-thermal spike and a hydro-thermal drill. The function and field use of these units is briefly discussed.

INTRODUCTION

Many mountain glaciers in mid latitudes and some glaciers on the Arctic Islands may be considered as temperate. The temperature below a surface active layer is at or close to the melting point. During the summer, an intensive melting occurs and free water may be encountered both at the surface and in the body of the glacier.

The thickness of these glaciers is mainly between 100 m and 500 m, but occasionally thicknesses of 800 m or more may be encountered.

In the accumulation zone, there may be thick firn layers while in the ablation zone,moraine and other deposits may be found in various concentrations.

DESCRIPTION OF DRILL UNITS

The Electro-thermal Core Drill ETB-1

An electro-thermal core drill, model ETB-1, (Fig. 1) was developed for core drilling in temperate ice (Morev, 1972). It consists of an annular bit or shoe attached to the lower end of a core barrel, to which are attached a set of core grippers. At the upper end, there is an end cap assembly and a spring loaded cable termination.

The ETB-1 differs from the ETB-3 unit (Morev, 1974) by the absence of the piston, the double core barrel and the filler tube.

After the drill has been lowered into the hole, the power is supplied to the drill heaters, causing melting of the ice there. The advance rate of the cable is controlled by the tension on the cable that is measured by means of a block balance. The power load on the drill heaters is controlled by means of the voltage controls on the operators panel. When the bore hole becomes contaminated with debris, the speed of drilling is seen to be reduced. To restore the speed, it is necessary to clean the bore hole bottom. To do this, a conical nosed heater unit is lowered to the base of the bore hole on the next run, and a conical hollow is melted into the ice. The debris then collects in this conical space and most of it may be brought up still trapped at the top of the next core. During such coring operations, the hole is usually filled with melt water which prevents hole closure.

The drill has the following specifications:

Outer diameter of shoe,	108 mm
Inner diameter of shoe,	84 mm
Bore hole diameter,	112-120 mm
Core diameter,	78-82 mm
Length of drill,	1.5-3.5 m

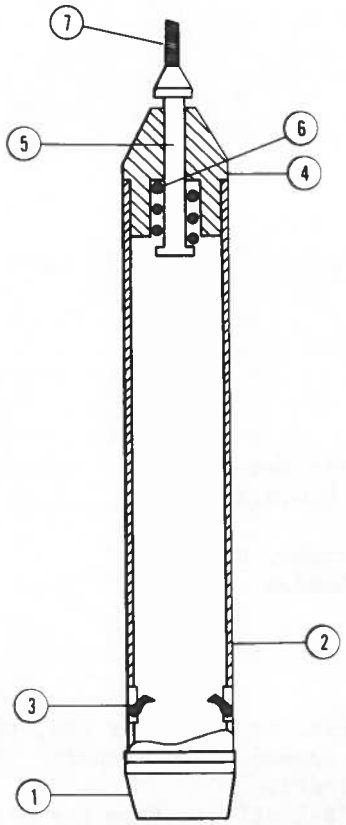

Figure 1. ETB-1 electro-thermal core drill. (1) Heater shoe. (2) Core barrel. (3) Core grippers. (4) End cap assembly. (5) Cable termination unit. (6) Spring. (7) Electro-mechanical cable.

Length of core,	1.0-3.0 m
Drill weight,	15-40 kg
Power intake,	1-3 kW
Drilling rate,	2-6 m/h

The electro-mechanical cable is a single core, armored type with a diameter of 8.6 mm. Power is transmitted through the core and the armor. A manual or electric drive winch is used to feed the cable which is normally 500 m long. For this depth drilling, a generator of about 4 kW is sufficient.

The Electro-thermal "Needle" Drill

This unit, shown in Fig. 2, was developed for hole drilling without core recovery. It consists of a conical heater bit attached to a pipe by means of a coupling nut and connector. To the upper end of the pipe is attached the cable termination assembly which is surrounded by the spring loaded hole centering device. Power is transmitted through the

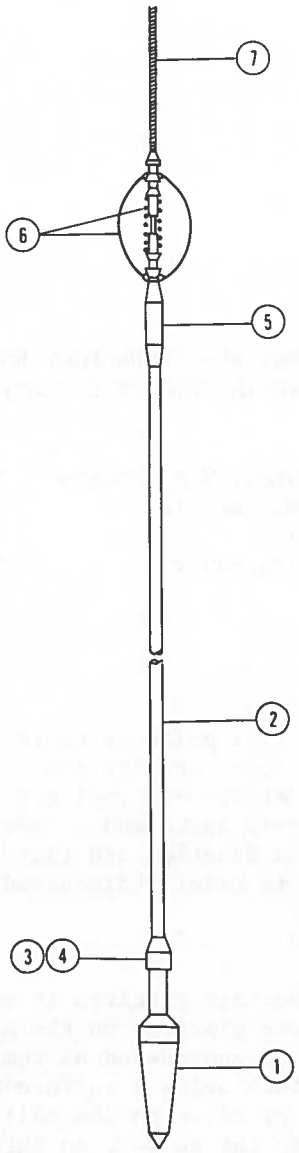

Figure 2. Electro-thermal "Needle" drill. (1) Conical heater bit. (2) Central pipe. (3) Coupling nut. (4) Connector. (5) Cable connector assembly. (6) Spring loaded hole centering device. (7) Electro-mechanical cable.

core and the armor of the cable. If clay and sand accumulate significantly at the base of the hole, the heaters may over heat and burn out.

The drilling rates should be monitored constantly, and the heater power varied in direct relation to the drilling speed. The tension in the cable is controlled by means of a block balance.

The drill has the following specifications:

Drill bit diameter, 40 mm

Bore hole diameter, 42-55 mm
Length of drill, 1.5-2.0 m
Drill weight, 5-7 kg
Power intake, 1-3 kW
Drilling rate, 6-18 m/h

Core and bore hole drilling in temperate glaciers of the Caucasus, Pamirs, Polar Urals and Spitzbergen has been carried out since 1970 (Suhanov, *et. al.*, 1974; Zagorodnov and Zotikov, 1981). Several tens of bore holes have been drilled to an accumulated length of 7 km. This includes more than 1 km of cored hole. Generally, holes were drilled to bedrock, the maximum depths being 368 m for cored holes and 586 m for uncored holes.

The Hydro-Thermal Drill

For the rapid drilling of shallow (20 m) holes in clean or contaminated ice, a mobile hydro-thermal drill was constructed (Fig. 3). The holes may be needed for installing ablation cables, or for measuring the thickness of ice mounds.

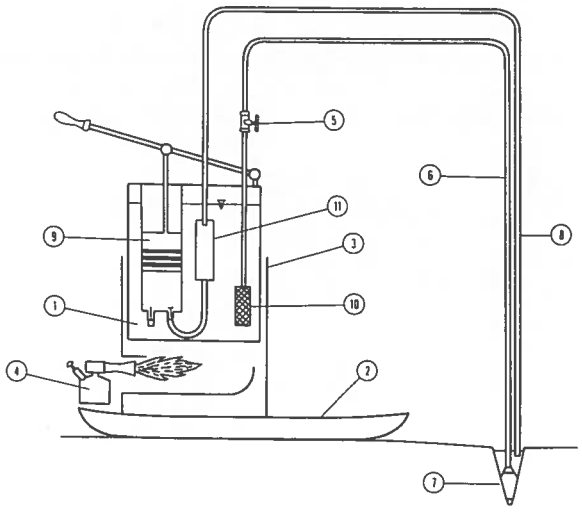

Figure 3. Hydro-thermal drill unit. (1) Water tank. (2) Sled resting on ice or snow surface. (3) Weather protection housing. (4) Gasoline blow torch. (5) Control valve. (6) Pipe leading to the drill head. (7) Drill tip, 1.5-2 mm diameter. (8) Water return pipe. (9) Piston pump for providing water pressure. (10) Inlet water filter. (11) Pump filter.

The drill has been successfully tested on the Pamir Glaciers and on various ice mounds in Eastern Siberia. It consists of a tank mounted on a sled and protected by a heat insulating housing, inside of which is mounted a blow-torch that burns gasoline. Water is heated in the tank and pumped via a flexible hose to the drill tip. On the return stroke of the pump, water in the hole is transferred back to the tank for reheating. The use of the two filters shown in Fig. 3 is very important to prevent the clogging of the drill and the pump while drilling in contaminated ice.

The weight of the unit is 30 kg. The drilling rate is about 1 m/min at a water flow rate of from 7 to 10 m/s.

FUTURE DEVELOPMENTS

There are plans for further improvement of the electro-thermal equipment, firstly, to make it possible to drill in contaminated ice without wasting excessive time cleaning the base of the bore hole, and, secondly, to recover an oriented core and a core not saturated with water from the melting of the firn.

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