



Antifreeze-Thermal Electrical Drill (ATED)

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Introduction

More than 10,000 m of ice core have been taken in Arctic and Antarctic glaciers (1-5) by ATED. The deepest borehole in Central Antarctica (Komsomolskaya Station) drilled with ATED is 870 m in depth. The ice temperature is -53°C . Drilling was stopped at 800.6 m. After eleven months, drilling operations resumed. Investigation of the ice structure shows that fracture of the ice core due to thermal shock takes place at temperatures below -15°C . Positive results of directional drilling by ATED and other thermal drills in cold and temperate glaciers also exist (6). At temperatures from 0 to -25°C , the mean penetration rate of an ATED was about 400 m/week. As a test, the first 110 m were drilled during a 24-hour period. The ethanol requirement was 10 to 50 percent of the borehole's volume.

The principle of operation of former ATEDs (Figure 1) is that the drill is immersed in an antifreeze solution (ethanol/water, glycols, salt water, etc.) in the borehole. The drill tip is fitted with a heating element that melts the ice. The melt water mixes with the antifreeze solution. The concentration of the antifreeze maintains the freezing point equal to the temperature of the surrounding ice. The primary specifications of the prototype antifreeze-thermal drill are given in Table 1.

ATEDs offer the following characteristics:

- Simple mechanical structure.
- Relatively low construction cost.
- Short length allowing for smaller support shelter.
- Penetration rate comparable or higher than mechanical drills.
- Can be adapted for directional drilling.
- Low environmental impact from drilling fluid.
- Low transportation costs.

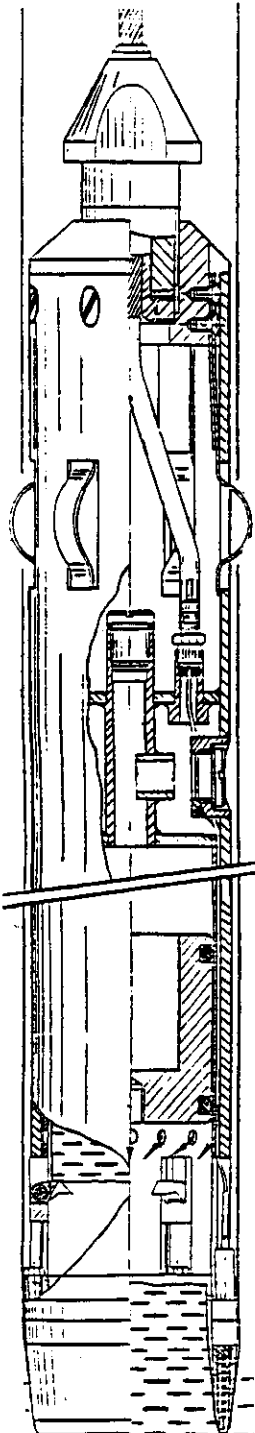
Table 1. ATED specifications

Temperature of ice	0-33°C
Heater, outer diameter	108 mm
Heater, inner diameter	84 mm
Borehole diameter	114-118 mm
Ice core diameter	78-80 mm
Drill length	1.5-6 m
Ice core length	1-7 m
Drill weight	25-180 kg
Power consumption	3 kw
Drilling rate	4 m/hr
Penetration rate	210 m/wk
(12 hr/day; 560-m depth)	

Advanced Design ATED

The new design of the antifreeze-thermal electrical drill may lead to the solution of current problems by:

- decreasing thermal shock in an ice core, and
- increasing travel speed of the drill in the borehole containing high-viscosity ethanol-water solutions.



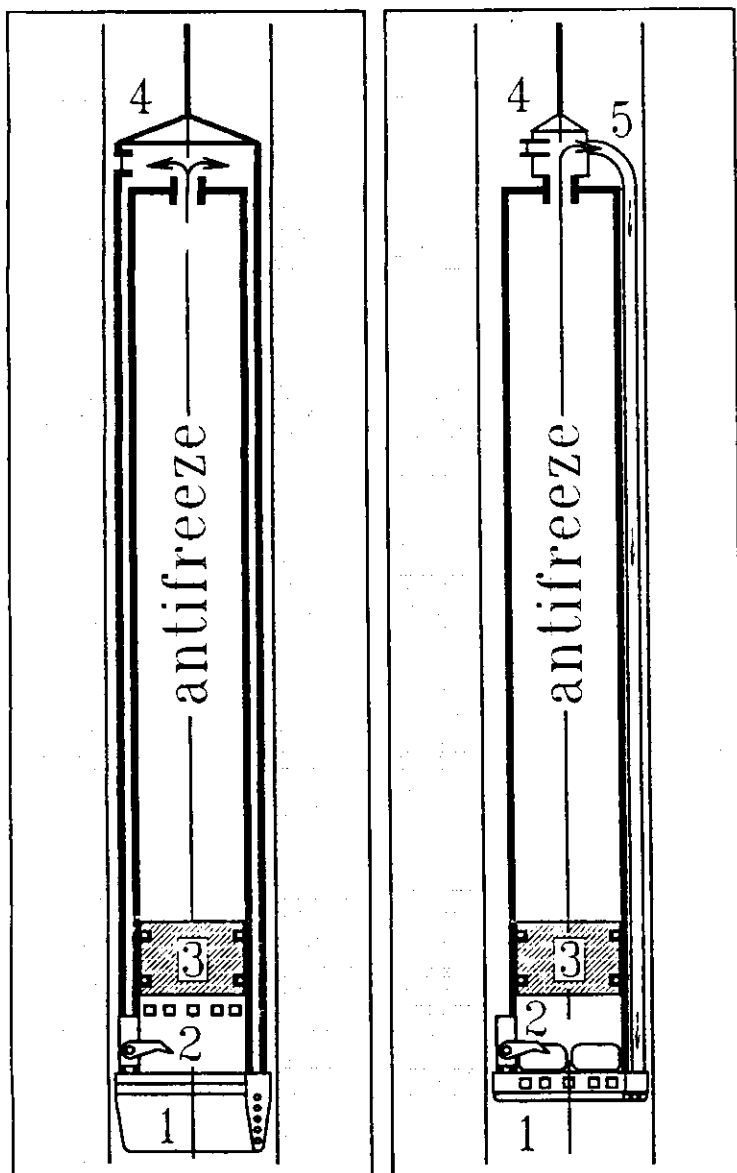


Figure 1. Antifreeze-thermal electrical drill

- 1- Heater bit
- 2- Core dogs
- 3- Piston
- 4- Cable termination assembly

Figure 2. Modified ATED

- 1- Heater bit
- 2- Core dogs
- 3- Piston
- 4- Cable termination assembly
- 5- Antifreeze bypass tube

Numerical modeling based on experimental data (7) shows that the magnitude of the thermal elastic stresses in the ice core due to the drilling-melting process can be reduced from 5 to 10 times. This should allow for high quality ice cores to be obtained from a glacier with the temperature at -60°C .

The clearance between the new thermal drill and the borehole wall can be increased as much as two times, compared to the former drill (Figure 2). A lowering and raising speed of 0.5 to 0.7 m/s can be expected at a temperature of -60°C .

Prospective Advantages of Antifreeze-Thermal Electrical Drilling

- May be adaptable to drilling deeper than 1000 m in temperate or cold ice.
- Predicted (7) thermal elastic stresses in ice cores will decrease, which may result in reduced penetration of ethanol in ice.
- Penetration rates are expected to increase substantially over the older models (excess of 400-500 m/week at a temperature of -60°C).
- Can be used for directional drilling.
- Smaller shelter size is required for an ATED than for fluid-filled mechanical drills.
- Drilling costs may be reduced for deep and intermediate drilling, compared to other methods.

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