ELECTROCHAUDE : RECENT DEVELOPMENT IN BOREHOLE DRILLING

by

Claude Rado, Claude Girard and Jacky Perrin
Laboratoire de Glaciologie et Géophysique de l'Environnement
Centre National de la Recherche Scientifique
Grenoble, France.

In order to study different aspects of glaciers, the scientists need good quality cores, but also holes bored in the ice. The LGGE has developed core drilling systems and different kinds of boring systems :

- A hot water drill very efficient but bulky and heavy equipment. Its transportation from the valley to glaciers needs the use of a helicopter.

- A steam drill, a light and compact device, portable by men, which is used to drive in wooden stakes. Its efficiency decreases below 15 m deep because of the hydrostatic pressure of the water in the hole.

- A hot point drill, in which an electrical heating element is embeded in silver. It allowed us to measure ice thickness and to put in metallic wires for deformation measurements by inclinometry. But it has three main disadvantages :

- the cost of the head due to both the silver price and the sophisticated fabrication.

- it can be overheated if not immersed in water and can be destroyed.

- it loses its efficiency when the ice contains much rock debris.

For these reasons, we developed a new system called Electrochaude.

DESCRIPTION (Fig. 1)

The external part is a stainless steel tube of 28 mm in diameter and 1.6 m long.

Beginning at the top we find :

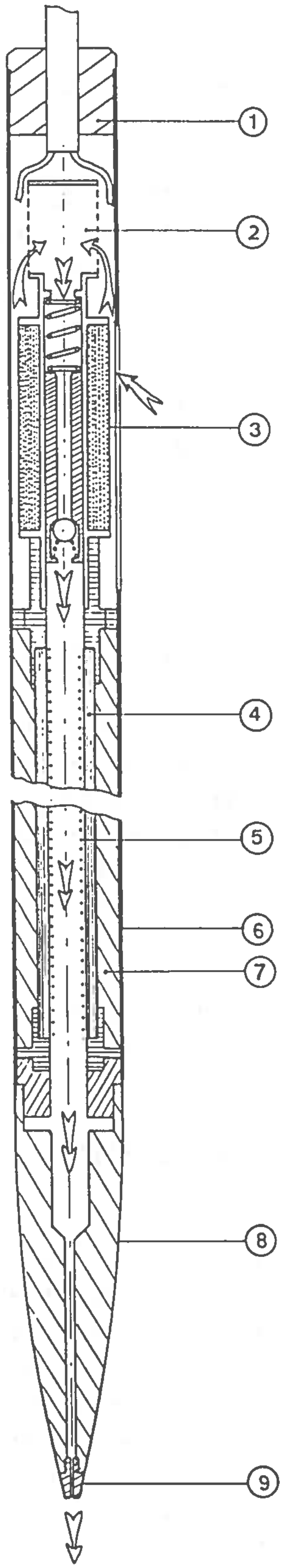
- The cable anchorage and the electrical connection.

- The pump (Fig. 2)
  It is an electromagnetic pump, supplied by alternating current with a diode in series which suppresses one wave. The piston is a magnetic core and moves alternately at the frequency of the power supply.

- A filter stops even the finest solid impurities.

- The internal ceramic tube has two functions :

  - as a water duct,



- as a heating element housing.

  It has a 12 mm external diameter and 8 mm internal diameter.

- The Nichrome heating wire is coiled helically. It was calculated to dissipate more than 1.6 kW in air without damage.

- The nozzle, made of brass. Its shape was determined according to Taylor (1984).

Initially, the nozzle had a short parabolic shape and the water flow was adjusted by a needle valve. A new shape, having a long, smooth parabolic taper, increased the drilling rate from 8.5 to 14 m/h.

Tips with different size holes can be screwed to the nozzle end.

OPERATION

Water is sucked through the filter, pumped into the ceramic tube were it is warmed by the heating element. It flows as a steady jet, powerful enough to scatter the insulating layer of sand at the hole bottom.

The water jet temperature is about 35°C.

The electrical cable is hand held so that the drill is always suspended.

Fig. 1 Schematic diagram of the Electrochaude drill : (1) Cable anchorage ; (2) Filter ; (3) Electromagnetic pump ; (4) Ceramic tube ; (5) Heating wire ; (6) Stainless steel external tube ; (7) Weight ; (8) Nozzle ; (9) Tip.

On the surface, a transformer increases the supply voltage to reduce the line losses.

The drill is supplied by a 3.2 kVA generator, but it can be also supplied by a 2 kVA generator when the equipment has to be back-packed.

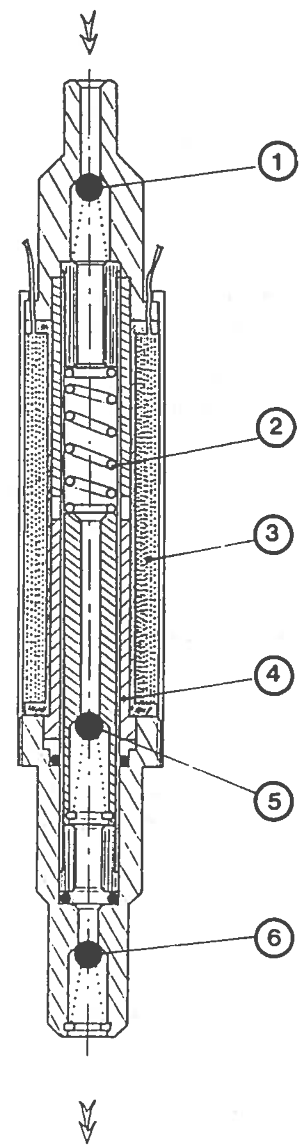


Fig. 2 Electromagnetic pump.
(1) Bottom valve ; (2) Pumping spring ; (3) Coil ; (4) Piston forming magnetic core ; (5) Priming valve ; (6) Delivery valve.

TECHNICAL CONSIDERATIONS

In temperate glaciers, the drilling rate of Electrochaude depends on several parameters, predominently :

- the heating power
- the nozzle shape
- the water jet pressure. This pressure is adjusted by the nozzle hole diameter.

At the Mer de Glace glacier, the maximum drilling rate was obtained with the smallest nozzle hole, in spite of a low water flow rate. This was due to the fairly high jet pressure.

ELECTRICAL SUPPLY (Fig. 3)

The electrical supply for both the pump and the heating element is arranged in series. Then we avoid problems due to power shortages in the pump coil. We need also a second diode to get the two waves of current in the heating element.

In order to protect the pump, a bimetallic switch is also mounted in series in case of lack of water.

HOLE QUALITY

Both the verticality and the regularity of the hole depend on the care of the driller who controls wether the drill is suspended or not by holding the cable. Initially, water was sucked up just above the nozzle and the drill recovered a few part of solid debris in the space between the ceramic tube and the external tube. This space was replaced by a thick stainless steel tube to increase the drill weight.

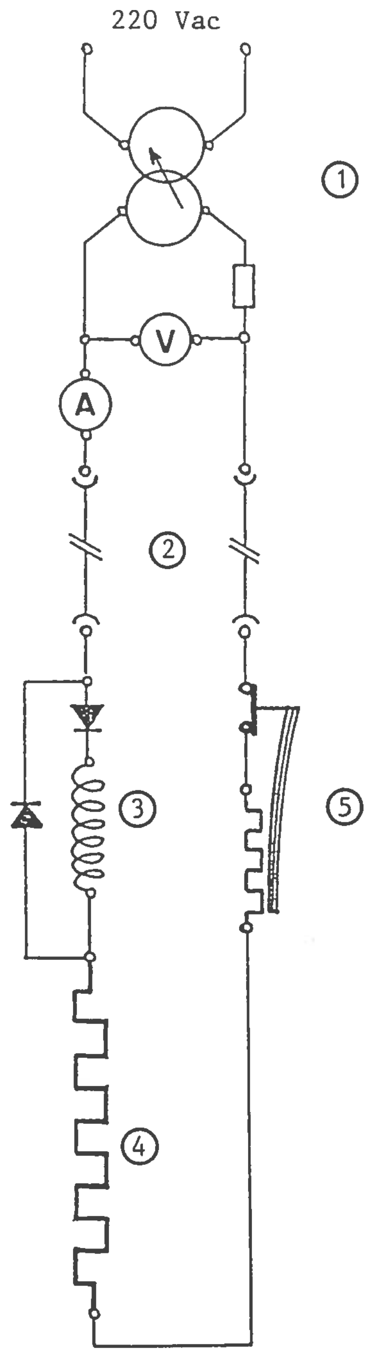


Fig. 3 Electrical diagram.
(1) Transformer ; (2) Cable ; (3) Pump coil ; (4) Heating element ;
(5) Bimetallic switch.

RELIABILITY

The main causes of malfunction were electrical shortage and spring failure in the pump. Both these problems were eventually overcome.

In the first version, all the elements (electrical connection, filter, pump and ceramic tube) were cased in the external tube and to fix the drill, it was necessary to pull out all the whole assembly. Now the pump can be changed without dismantling the drill. Problems of shortages in the connection were solved by two small plugs and a separate mechanical anchorage of the cable.

HOLE STARTING

The Electrochaude system can work only completely immersed in water. We have used both the steam drill and the hot point drill to bore through the snow and to start the two first meters in the ice. When the glacier surface is "dirty", the hot point drill loses its efficiency. Moreover, when it is used in snow or porous firn, it cannot work at full power. The steam drill is in this case a better starting drill.

In order to simplify hole starting, we have tested successfully a modified system using the Electrochaude drill, in which the pump is on the surface of the glacier and immersed in a water vessel. The drill is supplied by water through a rubber hose 25 m long and then heated in the ceramic tube. An electrical cable which runs along the rubber hose supplies the heating element.

FIELD EXPERIENCE

The drill was used to bore more than 1500 m of holes in temperate glaciers, but also in moderately cold glaciers such as Austfonna

Ice Cap, Svalbard (Spitzbergen). In this case, drilling needs the use of antifreeze.

CONCLUSION

This compact drill facility has proved its effectiveness. It is easily transported and able to drill in ice containing small rock debris.

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