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BOREHOLE LOGGING DEVICE AT DOME F, ANTARCTICA

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Abstract: A borehole logging device is newly developed for deep drilling to start from 1995 at Dome F, Antarctica. The device is designed to measure the diameter, inclination and azimuth of a hole, ice temperature and fluid pressure. A logging sonde, 2.35 m in length and 114 mm in diameter, has two sets of stabilizers and a caliper with three contact points. The possible range of measurement is from 130 to 170 mm in hole diameter. The data are transmitted by a microprocessor mounted in the sonde to a personal computer at the ice sheet surface.

1. Introduction

Measurements of boreholes provide useful information to drilling operations and studies on dynamics of glaciers and ice sheets (*e.g.* GOW, 1963; PATERSON, 1977; THWAITES *et al.*, 1984; GUNDESTRUP and HANSEN, 1984; FISHER and KOERNER, 1986). The Japanese Antarctic Research Expedition (JARE-25, -26 and -27) carried out measurements of borehole diameter and inclination at a 700 m deep hole in Mizuho Station (70°42'03"S, 44°17'36"E; 2247 m a.s.l.), East Antarctica in 1984-1987 (KAWADA *et al.*, 1986; OKUHIRA *et al.*, 1987). Because the hole was not filled with liquid throughout the drilling, closure rates of the hole were considerable. The diameter gauge used for the Mizuho hole is a tandem one developed by the Institute of Low Temperature Science (NARUSE *et al.*, 1985). It has two separate calipers 0.53 m apart, each having three contacting steel wheels. By analyzing the result of closure rates of the hole, NARUSE *et al.* (1988) obtained a power law of ice creep in the stress range from 0.8 to 1.65 MPa at a temperature of –35°C.

Deep drilling is planned from 1995 to 1997 at the summit of Dome F in East Antarctica (WATANABE, of Special Session Report 1 in this issue). A borehole logger for this drilling project is being developed. An outline of the device is presented.

2. Description of New Borehole Logger

The new borehole logging system consists of a logging sonde, a cable for signal transmission and a data processor (personal computer). Figure 1 shows an overall illustration of the logging sonde, the length of which is 2.35 m; the diameter of the cylindrical body is 114 mm. Some sensors and a central processing unit (CPU) are located in the middle part of the sonde (Fig. 1). An armored cable with four conductors is used: two are for power supply and two are for data transmission.

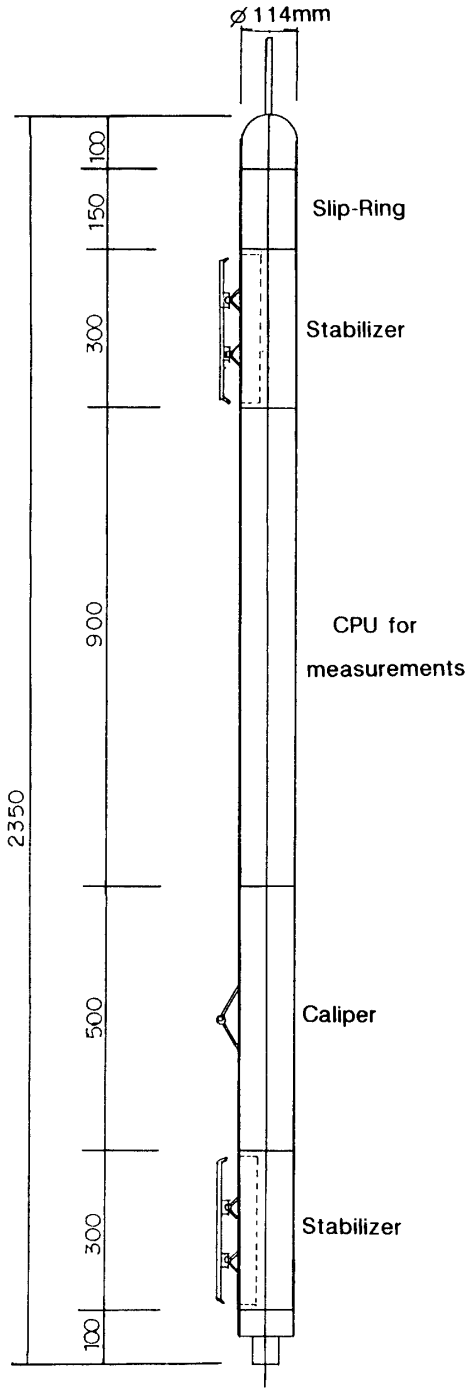

Fig. 1. Schematic of the logging sonde.

2.1. Stabilizers

Two sets of stabilizers are mounted in the upper and lower parts of the sonde in order to align the sonde with the hole axis. Each stabilizer has three pantographs at intervals of 120 degrees (Fig. 2). The length of the steel ski is 300 mm.

2.2. Caliper

A caliper with three contact points is attached between two stabilizers (Fig. 3). The

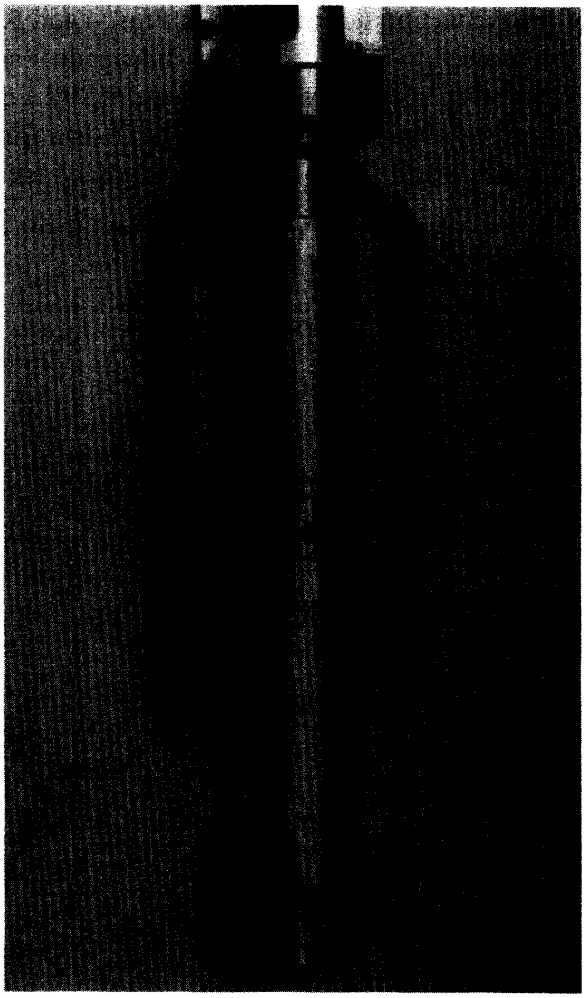

Fig. 2. The stabilizer.

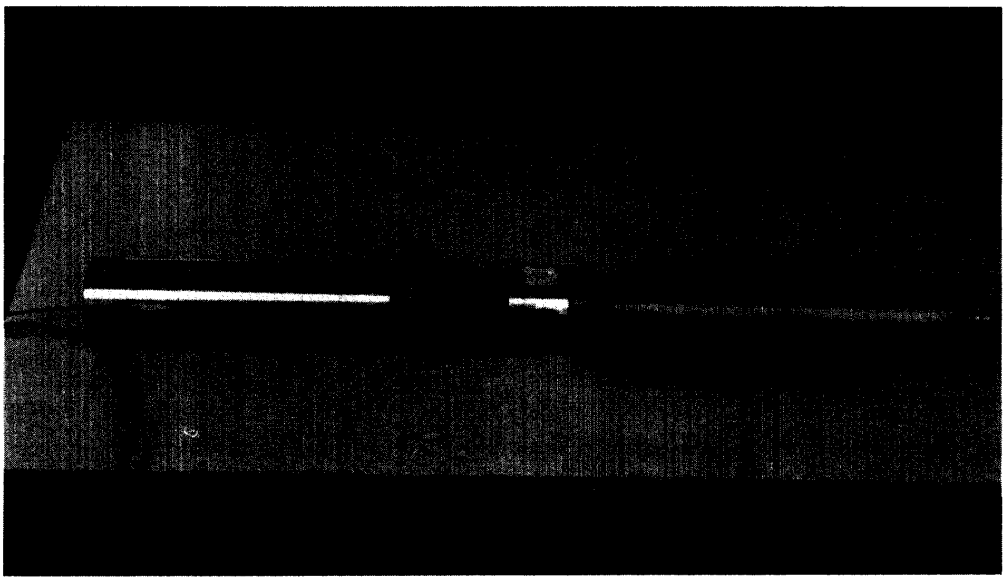

Fig. 3. The lower half of the sonde.

detailed design of one of the contact points is shown in Figs. 4 and 5. Three wheels at the tips of the mobile arms are pressed to the hole wall by independent springs. The diameter change is converted into axial displacement which is measured by a differential transducer (see Fig. 5). The diameter can be obtained by averaging three data from three sensors. The range of measurement is from 130 to 170 mm; the resolution of measurement is 0.1 mm and the accuracy is ±1 mm.

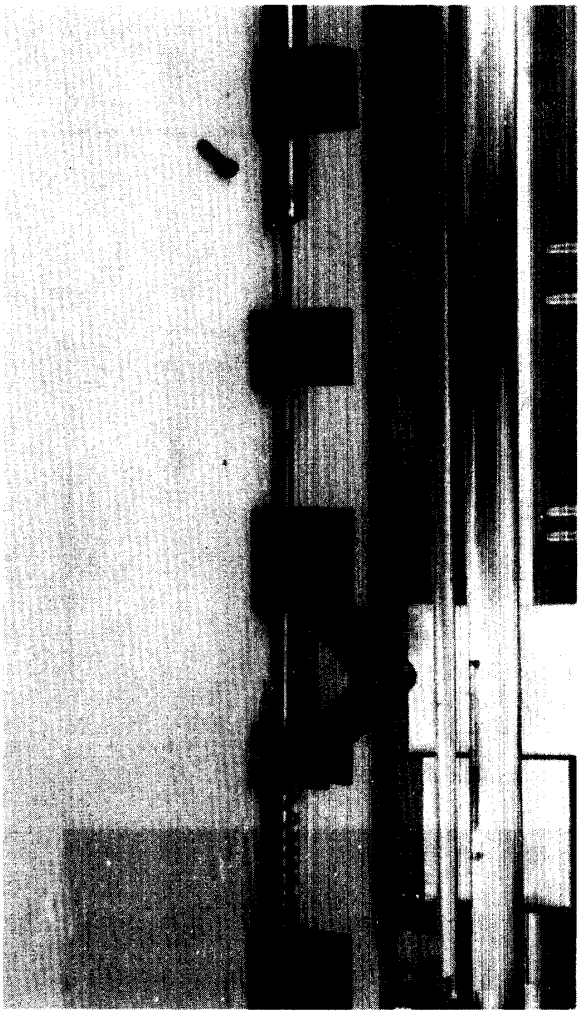

Fig. 4. The arm and wheel of the caliper.

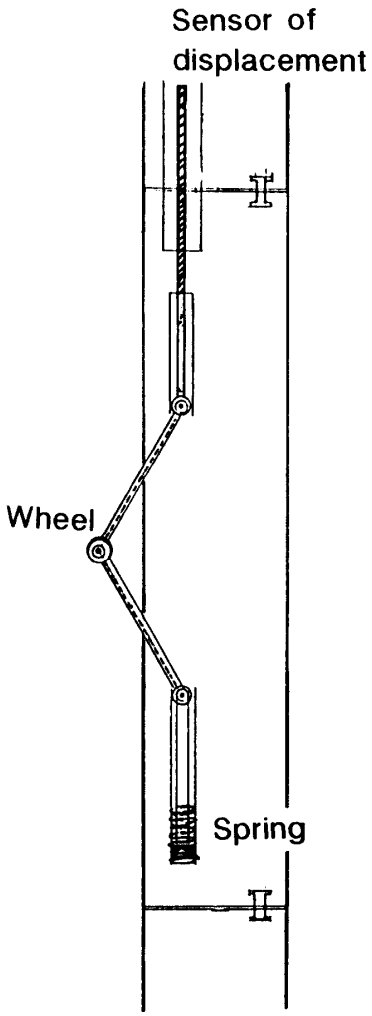

Fig. 5. Detailed design of the caliper.

2.3. Inclinometer and azimuth sensor

A servo accelerometer is used to detect the inclination of the sonde, and a geomagnetic sensor (hall element) for its azimuth. These sensors are located in the middle part of the sonde. Ranges of measurement of inclinometers are 5 degrees and 15 degrees. Although the accuracy of measurements depends strongly on alignment of the sonde with the hole axis, we can estimate it to be about 0.5 degree for inclination and 1 degree for azimuth.

2.4. Thermometer and pressure gauge

A Pt-resistance thermometer (resolution 0.05°C) is attached to the surface of the

stabilizer ski in order to contact well the ice wall. A pressure gauge, which measures 30 MPa maximum, is placed at the top of the sonde.

2.5. Microprocessor

Data are processed in the CPU of the sonde and transmitted at intervals of three seconds via a pair of modems (modulator-demodulators) to a personal computer at the ice

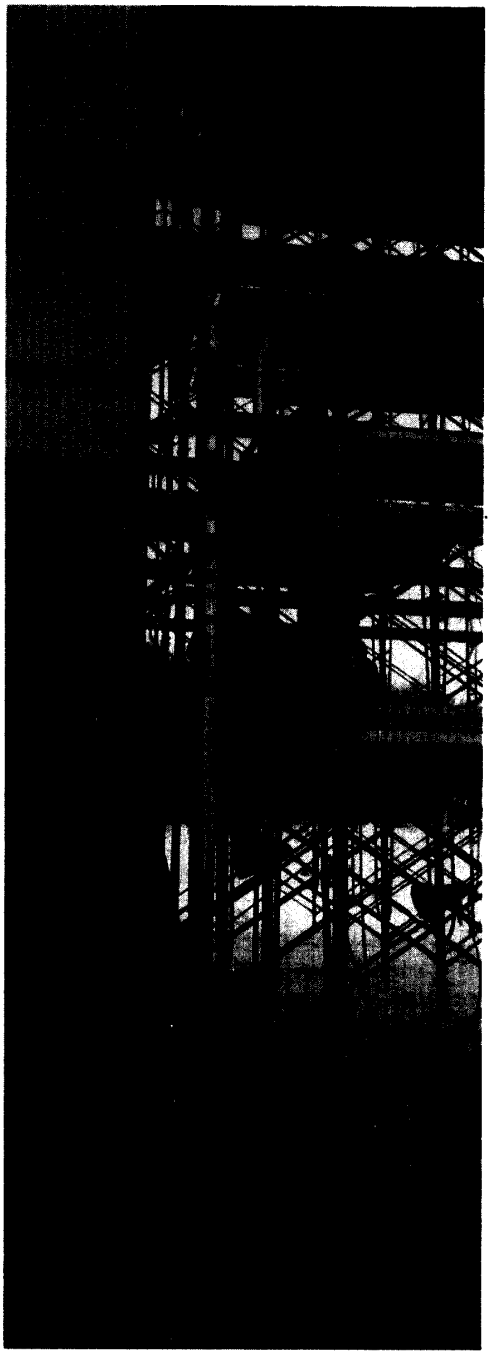

Fig. 6. A photograph of the ice tower test.

surface. Power to be supplied is AC 100 V and about 50 W including a small heater in the CPU. The depth in the hole is recorded as the length of the winch cable.

3. Conclusion

Using the prototype borehole logger, test measurements were made (Fig. 6) in February 1993 at a 15 m high artificial ice tower in Rikubetu, Hokkaido (TANAKA *et al.*, 1994). From repeated measurements of hole diameter, the accuracy of the caliper was found to be within 0.5 mm. We conclude that the present borehole logger device can be used for the Dome F operation and should provide sufficient information. However, more tests in a cold room and in a high pressure liquid are needed.

Acknowledgments

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