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A RESISTANCE GAUGE FOR MEASUREMENT OF ICE PRESSURE

by

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Direct measurement of ice pressure has been carried out at certain dams in the United States [1,2]. This has been done by placing small box-form gauges at desired points e.g. on the dam wall. The pressure thus acts at right angles to the steel lid of the box, making it bend, the bend depending on the dimensions and elasticity of the plate. Certain models of gauges have a mechanical indentor for reading the pressure (»Indentor Gauge»). In some other types of gauge, the measuring element is a coil of fine constantan wire wound on small glass support rods. When the pressure is applied to the gauge, the wire coil is stretched. The change in the resistance of the coil may be used as a measure of the pressure exerted on the gauge (»Resistance Gauge»).

The gauge which we have now developed has a steel membrane with a strain gauge glued on its back surface. The bending of the steel membrane under pressure stretches the strain gauge somewhat, and the pressure can be measured directly with a standard bridge. In order to be able to measure the components of the pressure at the same time, we have placed several steel membranes in the same gauge.

The structure of the gauge is as follows: The frame itself is a three-faced prism made of steel (Fig. 1). Each face of the frame has an opening in which a steel membrane (diameter $d = 40$ mm and thickness $h = 1.5$ mm) is placed. There is another similar opening for the insertion of a steel membrane in the base of the frame. The membranes are fixed with screws

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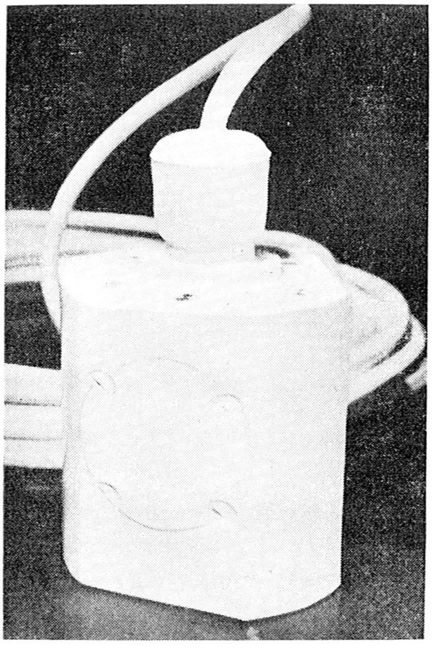

Fig. 1. Resistance gauge for the measurement of ice pressure.

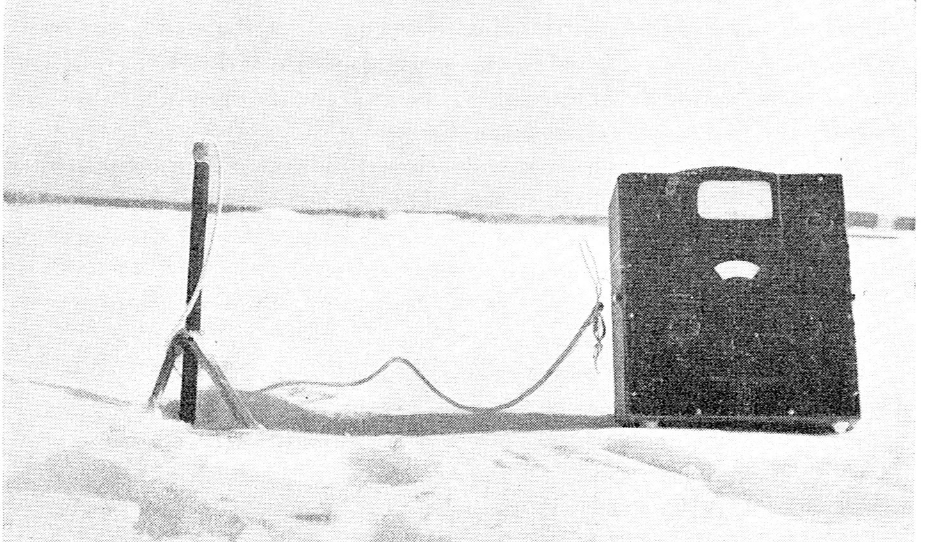

Fig. 2. The gauge in function.

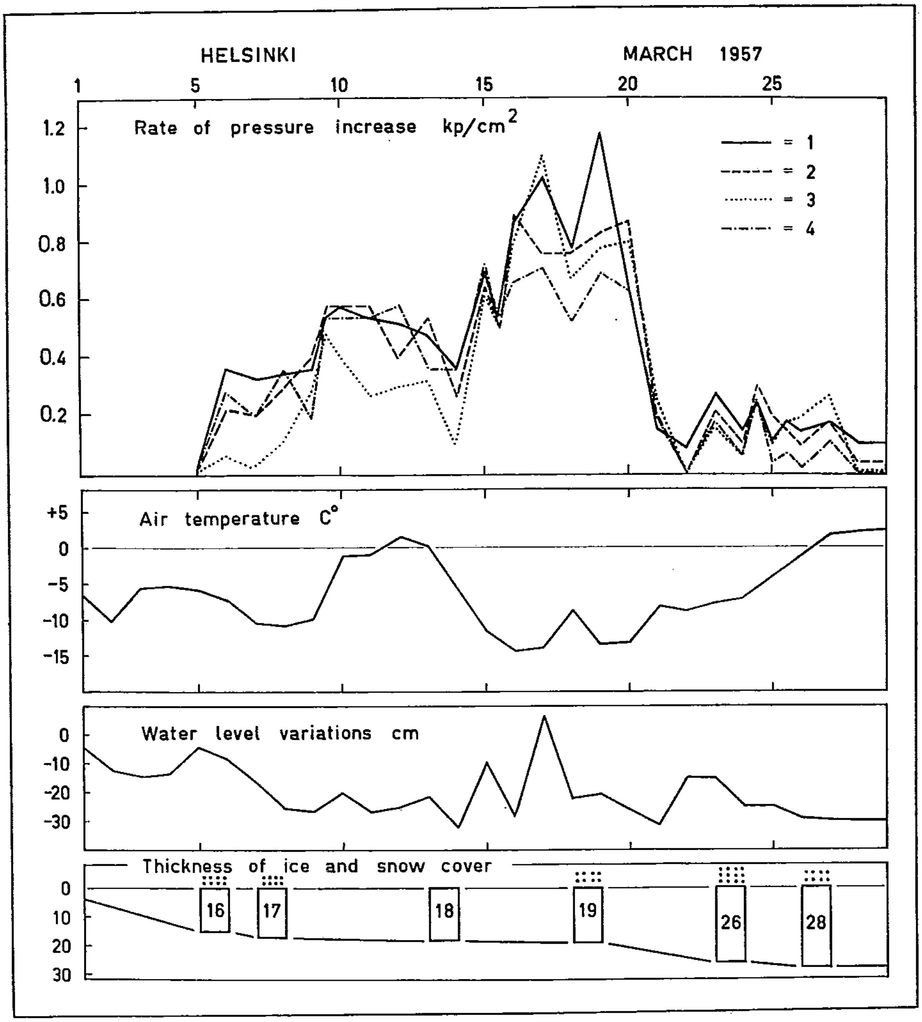

Fig. 3. The results of measurements, March 5—29, 1957, on sea-ice near Helsinki. Membrane i was parallel to the coastline; membrane 4 was in the base of the frame.

and tightened with special glue. A strain gauge (*Philips* PR 9214 B) is glued on the inner surface of each membrane. To compensate for changes due to temperature, one strain gauge is placed on the free steel membrane inside the gauge.

The measuring wires are threaded through a hole at the upper end of the frame. As the exit point of the wires proved susceptible to damage in the experiments, a long protective metal pipe was attached to the frame (Fig. 2). In the later model it is replaced by a short rubber pipe. The exit point of the wires is tightened carefully. Finally, the gauge and wires are painted white in order to reduce the effect of solar radiation.

The gauge was calibrated in a pressure container holding liquid. The calibration curve under the pressures used (0—10 kp/sq. cm) was linear. It is worth noting, however, that after a change in temperature the gauge balanced and began to show the correct value in about 15 minutes.

Resistance measurements in strain gauges may be made with standard bridges manufactured industrially.

To demonstrate the functioning of the gauge, on March 5, 1957, it was placed on the sea-ice near the island of Harakka, Helsinki, about 200 m from the shore. During the first days of the month fast ice had been forming here; its thickness at the moment of placing the gauge was 16 cm. A hole the size of the gauge was bored to the ice and the gauge was sunk into it until its upper edge was about 2 cm below the upper surface of the ice. The gauge was then allowed to freeze to the ice. During the period of measuring the thickness of the ice increased to 28 cm and there was snowfall on the upper surface of the ice, part of the snow hardening into ice (Fig. 3).

The gauge was read once or twice a day. Even on the next day, March 6, the gauge showed an increase in pressure. A considerable rise of pressure was noticed when the cold grew intense on March 15, which was due to the contraction of the upper ice layers as the temperature fell. The temperatures of the different ice layers, however, were not measured. The pressure lasted until March 20 when the readings of the gauge dropped close to the 0 mark. When removing the gauge, it was noticed that it had melted loose. As the prototype had not been whitewashed, the effect of the sun was evident even in relatively cold, yet bright weather. Later on it was ascertained that a hole had melted through the ice due to melted water which had trickled down from the surface. Inspite of this, the night frosts caused pressure. When placing gauges in a moving glacier, we have especially tried to prevent the possibility of melted water trickling down the wires leading to the surface.

REFERENCES

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