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Publisher's version / Version de l'éditeur:

Technical Paper (National Research Council of Canada. Division of Building Research), 1966-11

NATIONAL RESEARCH COUNCIL
CANADA
DIVISION OF BUILDING RESEARCH

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Reprinted from
Canadian Geotechnical Journal
Vol. III, no. 4, November 1966
pp. 246–250

Technical Paper No. 238
of the
Division of Building Research

OTTAWA
November 1966

Price 10 cents

NRC 9316

RESEARCH NOTE

A Compact Self-Contained Ground Temperature Recorder

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The study of ground temperatures is an important part of the permafrost research carried out by the Northern Research Group of the Division of Building Research, National Research Council. The determination of the mean annual ground temperature and the amplitude of temperature fluctuations at various depths in permafrost is of particular interest.

Various types of instrumentation are available and have been used in the field to measure ground temperatures. Intermittent and infrequent observations can be obtained using manually operated reading instruments, and continuous records using electronic recording equipment. There are a number of limitations and difficulties inherent in the use of such equipment, however. For frequent observations, manual methods are time-consuming, costly, and sometimes unreliable due to observer error, resulting primarily from difficult field conditions such as biting insects, marshy ground, and severe weather. Electronic recording equipment, which is usually rather complex, generally requires frequent and regular maintenance and servicing. Many northern locations are isolated or quite remote and access is difficult, if not impossible, at certain periods of the year. In addition, observers trained in the use and servicing of manually or electronically operated equipment are not usually available.

There was a real need, therefore, for a simple temperature-measuring device of reasonable accuracy which would run unattended for a period of at least one year. Such an instrument, which is relatively small, fairly rugged, self-contained, and which will operate at reasonably low temperatures, e.g. 0° F., has been developed at the Division of Building Research and is described in this note. When placed in a borehole it will continuously measure and record ground temperatures at a particular depth for a one-year period and will not require attention or servicing during that time.

DESCRIPTION OF INSTRUMENT

The instrument consists of two major components: a temperature-sensitive bimetallic strip and a battery-powered electric clock. Two 1½-volt flashlight-size mercury batteries connected in series are used as the power supply. The coil-wound bimetallic strip contracts or expands in response to temperature fluctuations and moves a pointer attached to one end. The pointer leaves a trace on a pressure-sensitive (wax-coated) paper fixed to a metal disk (3¼ in. dia.) which makes one complete revolution in one year. The disk is rotated, through an arrangement of gears, by the battery-operated electric clock motor. The complete assembly is placed in a moisture-proof metal canister (3¾ in. dia.

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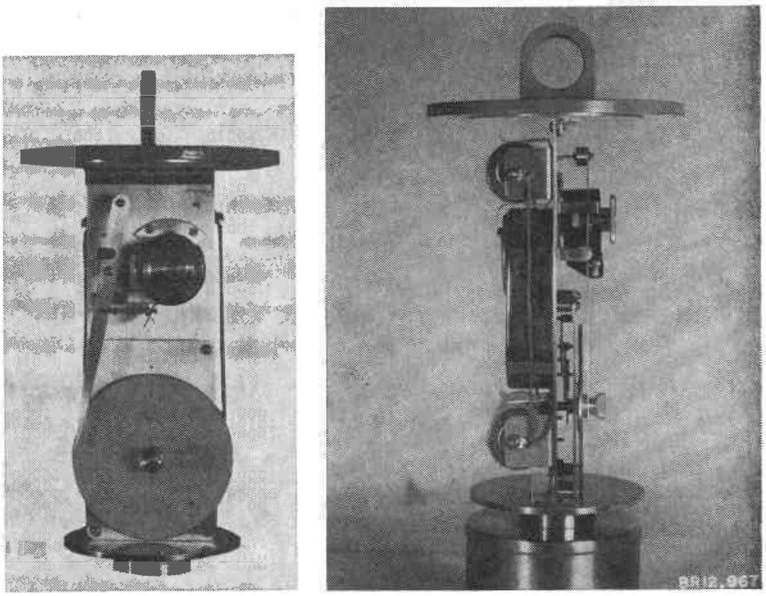
Canadian Geotechnical Journal, vol. III, no. 4. Nov., 1966. Printed in Canada.

by 11 in. long) for installation in the ground. Total weight of the instrument is about 7 lb. Two views of the device are shown in Figure 1.

Temperature fluctuations within a range of 20° F. can be measured with the instrument described here. Temperatures encountered in permafrost at depths of from 3 to 30 ft. may lie between 20° and 40° F. The temperature-sensing element is therefore positioned in the instrument so that the pointer will mark the dial accordingly. Stops are provided to prevent the pointer from running over the edge of the chart should the temperature range be exceeded.

After fabrication each instrument is adjusted and calibrated in the laboratory for the temperature range to which it will be exposed at a particular location. A special transparent template (lucite), on which 1° F. temperature intervals



(a) (b)

FIGURE 1. Ground temperature recorder. Left, front view; right, side view

are inscribed, is made up following calibration. When a record has been obtained temperatures can then be taken from the chart by placing the template over the waxed dial. A typical chart and template are shown in Figure 2.

Although the instrument has been designed to record relatively slow temperature fluctuations, it will respond fairly quickly to rapid changes in temperature. It should be noted that the time scale is compressed, i.e. quite short in length, and therefore this particular instrument is best adapted for situations where temperature changes take place rather slowly. For example, Figure 2(a) is a one-year record (actually 386 days) of ground temperature at a depth of 20 ft. A temperature change of about 0.5° F. during this period is recorded on a trace about 4.2 in. long. Laboratory tests and field checks indicate that the accuracy obtained is better than 1° F., probably about ± 0.5° F.

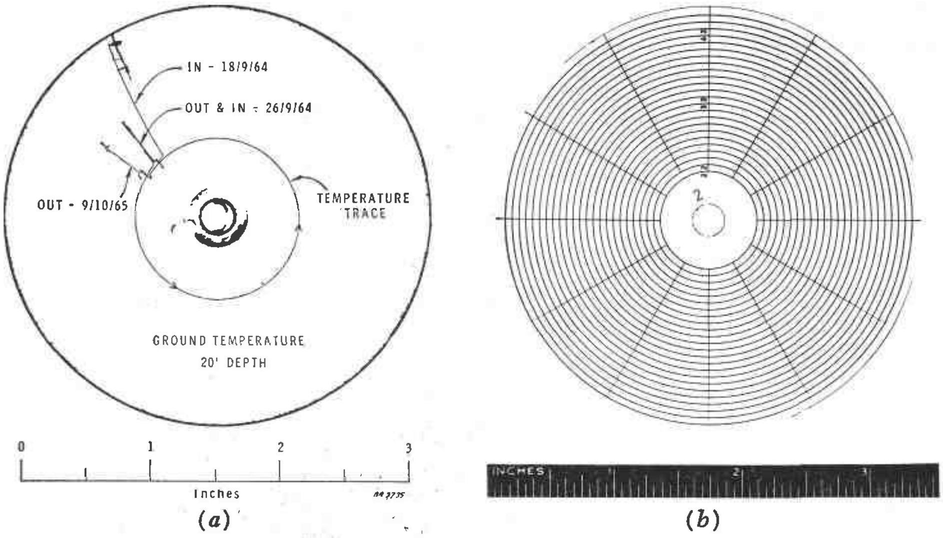


FIGURE 2. Ground temperature recorder, (*a*) One-year ground temperature record, (*b*) Temperature template

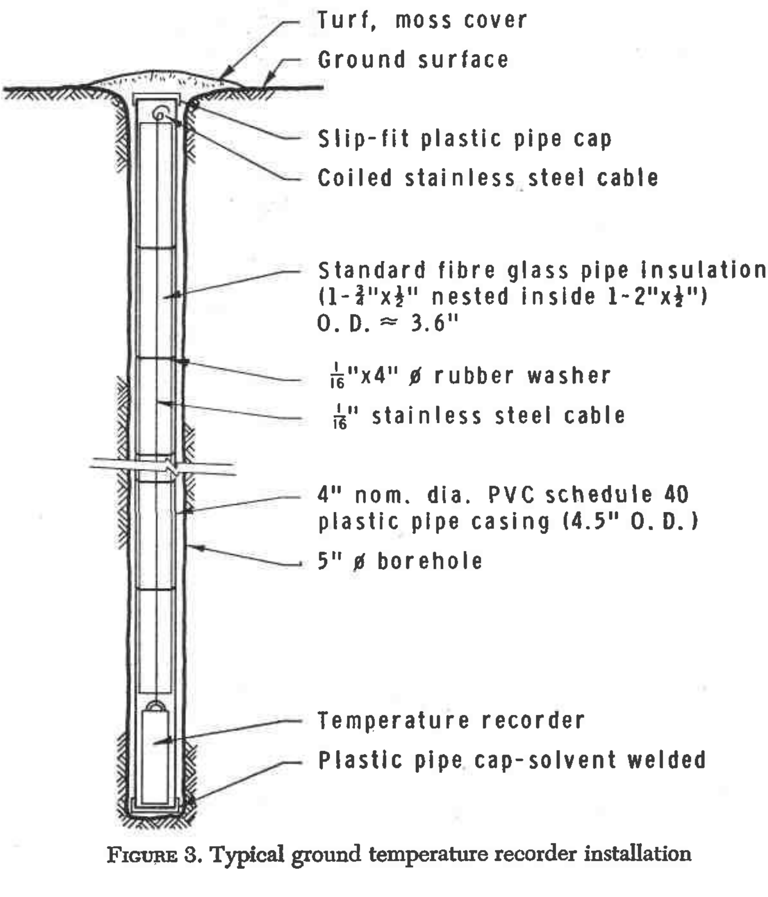


FIGURE 3. Typical ground temperature recorder installation

Field Installation

To install the instrument, a 5 in. dia. hole is drilled in the ground and cased with plastic pipe, tightly sealed by a plastic cap at the lower end to prevent entrance of water. The canister containing the instrument is then lowered inside the casing to the depth at which temperatures are to be measured. To minimize or eliminate temperature fluctuations within the casing as a result of air movement by convection, lengths of standard pipe insulation, separated by rubber washers, are slipped over the stainless steel cable used to lower and retrieve the canister. The casing is filled with insulation from the canister to the ground surface; insulation is also placed below the canister if required.

The casing extends to within 2 to 3 in. of the ground surface and is closed by a snug-fitting plastic-pipe cap. The top of the casing is covered with turf, moss or soil following installation of the instrument. A typical installation is shown in Figure 3.

Other Applications

Lake bottom water temperatures have also been measured using a slightly modified version of this instrument. All components of the water temperature device are virtually identical with the exception that a larger wax dial (5 in. dia.) is used to increase the range of temperature measurement to 40 F deg. The protective canister is correspondingly larger (6 in. dia × 12 in.). The canister (weighted if necessary and standing on three legs) is lowered to the

Figure 4. Water temperature recorder

bottom of the lake by a stainless steel cable. To the top end of the cable is attached a set of brightly painted copper floats which is positioned below the bottom of the ice cover (usually < 5 ft. thick). To retrieve the instrument (the location of which is established from on-shore reference points and visual identification of the float) a looped cable is lowered from a boat, or through a hole in the ice, and secured around the floats. The assembly is then pulled to the surface. A typical unit prior to installation in an ice-covered lake is shown in Figure 4.

This instrument can also be used, of course, to measure temperatures in other environments, e.g., in buildings—attics, crawl spaces, etc. It is particularly useful whenever long-term records are desired at locations that are remote or where access is difficult. By simply changing the gear train the recording time can be lengthened or shortened. The recording range of temperature can also be increased or decreased by appropriately changing the size of the dial.

This combination of two standard components, a battery-powered clock and a bimetallic element, results in a very useful, compact temperature recorder that can be placed in a relatively small drill hole and will run unattended for a period of at least a year. It is entirely self-contained—that is, no external power source, read-out apparatus, or accessory equipment of any kind is required; nor does a shelter have to be provided on the ground surface. Temperatures measured can be read directly on the chart which is preserved for a permanent record. Details of the instrument can be obtained by writing to the Division of Building Research, National Research Council, Ottawa, Canada.

Acknowledgments

The idea for the device resulted from discussions within the Division of Building Research. Mr. C. St. Jacques and Mr. R. Tetu of the Division carried out the major design and development work. To them much credit and sincere thanks are due. This is a contribution from the Division of Building Research, National Research Council of Canada and is published with the approval of the Director of the Division.