Soil temperature installation at Prince George, B.C.

Eden, W. J.

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/20338549
Technical Note (National Research Council of Canada. Division of Building Research); no. TN-252, 1958-06-01

NATIONAL RESEARCH COUNCIL OF CANADA

DIVISION OF BUILDING RESEARCH

No. 252

TECHNICAL NOTE

NOT FOR PUBLICATION FOR INTERNAL USE

PREPARED BY W.J. Eden CHECKED BY CBC APPROVED BY NBH

PREPARED FOR Mr. C.P. Harford, City Engineer, Prince George, B.C.

DATE June 1958

SUBJECT Soil Temperature Installation at Prince George, B.C.

SUMMARY

This report describes the instrumentation supplied to the City of Prince George to measure soil temperatures around water mains. The installation was made in November 1957 under the direction of Mr. C.P. Harford, City Engineer. Instructions are given for carrying out and recording the observations.

SOIL TEMPERATURE INSTALLATION AT PRINCE GEORGE, B.C.

by

W.J. Eden

To assist in the study of problems with frozen water services in Prince George, B.C., the Division of Building Research agreed to supply the necessary instrumentation to measure soil temperatures in Prince George. This report describes an installation made in the fall of 1957 under the direction of Mr. C.P. Harford, City Engineer. Instructions are given for making and recording the observations.

For the City of Prince George, the records will be used to determine the thermal regime of the soil surrounding buried water services. For the Division, records will be obtained for the general study of soil temperatures as related to climatic conditions.

The thermocouple circuit was prefabricated in the Division's laboratories in Ottawa and shipped to Prince George for installation in November 1957. A potentiometer became available in January 1958 and was shipped to Prince George so that temperature records began at that date.

The Installation

The site chosen for the installation was one of two suggested by the City of Prince George. It is known as the "Central Station" located on Harper Street on Lot 8, BLK55, DL937. The installation consisted of three strings of thermocouples, one over the water main, one at the centre of a snow-cleared street and the third in ground where a normal snow fall was allowed to accumulate. The soil conditions were uniform, consisting of sandy gravel, grading from 2 in. size to fine sand. Figure 1 is a site plan of the installation prepared from information received from the city.

String No. 1 was located 12 ft from the instrument hut provided by the city under a snow-covered surface. It consisted of 6 thermocouples placed at depths of 1, 2, 3, 5, 7 and 10 ft. The second string was situated under the centre of Harper Street. The string had 10 thermocouples at the following depths: 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 ft. The third string, placed over the water main, had 10 thermocouples at 2, 3, 4, 5, 6, 7, 8, 9 and 10 ft plus 1 thermocouple used to measure the temperature near the water main. The thermocouples were taped to a 2- by 2-in. wooden post to maintain the correct spacing.

The instrument hut was an 8- by 8-ft wooden shelter and provision was made for heating the hut when readings were being taken.

The Circuit

Figure 2 is a circuit diagram for the Prince George installation which consisted of several elements. There were three thermocouple strings each terminating in a junction box sealed with a bituminous sealing compound. From the junction box a copper lead wire from each thermocouple terminated in the rotary switch. One constantan lead, common to all the thermocouples in the string, terminated in the reference junction. The copper member of the reference junction was led through the switch to the potentiometer.

The thermocouples were made of 20-gauge copper-constantan duplex wire; each member was covered by polyvinyl chloride, and the two leads were encased in cotton impregnated with asphalt. The thermocouple points were protected by plastic tubing and were dipped in glyptol enamel. The duplex wire terminated in a metal junction box in which the copper members were connected to 20-gauge pvc-covered copper lead wire. The constantan members met at a common point and were led to the reference junction by a single 20-gauge constantan conductor.

The reference junction consisted of a thermocouple immersed in a thermos flask filled with crushed ice and water to maintain a temperature of 32°F.

The switch was a 28-point rotary type manufactured by Lewis Engineering Corporation. It is the type often used by the Division in thermocouple circuits. Table I lists the switch point numbers corresponding to the various thermocouples.

Before being shipped, the circuit assembly was checked and found to be accurate to ± 1°F. The potentiometer was a Rubicon portable model reading in millivolts; instructions for its use were included when the instrument was delivered. One precaution should be taken with this instrument - it must <u>NOT</u> be subjected to freezing temperatures.

TABLE I

Switch point No.	Thermocouple string No.	Depth below surface Ft.	Remarks
1	1	1	
2	1	2	
3	1	3	Under snow cover
4	1	5	
5	1	7	
6	1	10	
7	2	1	
8	2	2	
9	2	3	Under centre line of street
10	2	4	
11	2	5	
12	2	6	
13	2	7	
14	2	8	
15	2	9	
16	2	10	
17	3	2	
18	3	3	
19	3	4	
20	3	5	Over water main
21	3	6	
22	3	7	
23	3	8	
24	3	9	
25	3	10	
26	3	On 6 in water main at 7-ft depth	

The circuit diagram in Fig. 2 indicates the correct wiring for obtaining temperatures above 32°F. For readings below the freezing point it is necessary to interchange the leads to the potentiometer.

Reading the Potentiometer

To obtain readings, the potentiometer should be placed on a solid level base. It should be switched on at least 5 minutes before any readings are taken. When adjusting the instrument the first step is to centre the galvanometer. Coarse adjustment is made by turning the galvanometer knob. Fine adjustment is made by sliding the etched glass plate until the centre line coincides with the reflected cross hair.

The next step is to balance the instrument against the standard cell. This is done by turning the resistance knobs R1 and R2 as directed in the manufacturer's instructions. The balance of the instrument should be checked frequently while the readings are being made.

The emf's of the thermocouples are determined by pressing on the emf button. This button should not be depressed continuously otherwise a slight error is introduced.

The millivolt readings obtained are converted to temperatures by using the conversion table appended to this report.

Treatment of Records

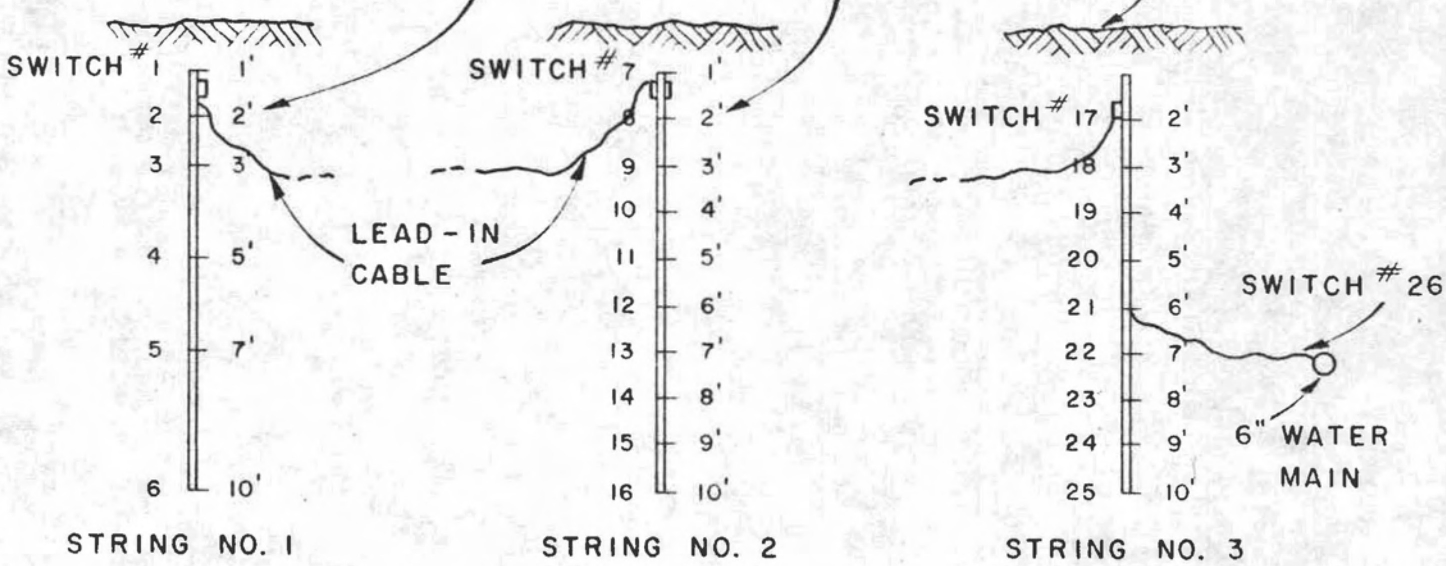
It has been found that seasonal variations in soil temperatures extend to a depth of about 20 ft. Daily variations extend to a depth of about 2 1/2 ft. To assess the magnitude of seasonal wave, temperatures need only be taken at intervals of 2 weeks or 1 month. The daily wave, if it is to be studied in detail, requires frequent readings. To overcome the daily variations it is suggested that readings be taken at the same time of day at each interval.

From this installation, the Division requires sufficient records to draw up a graph showing the monthly variations of temperature with depth. An example of this type of graph is shown in Fig. 6 of "Ground Temperature Investigations in Canada" by C.B. Crawford and R.F. Legget, Engineering Journal, Vol. 40 No. 3, March 1957, (Research Paper No. 33 of the Division of Building Research). To collect information on the general problem of frozen water mains, additional records such as the water temperatures, rates of flow and the depth of frost encountered in winter excavation would be helpful. It is believed that the meteorological records obtained from Prince George Airport by the Department of Transport will be adequate for correlation purposes. The form supplied by Mr. C.W. Jones of the Engineering Department, City of Prince George, if completed, will supply very acceptable information for the Division's records.

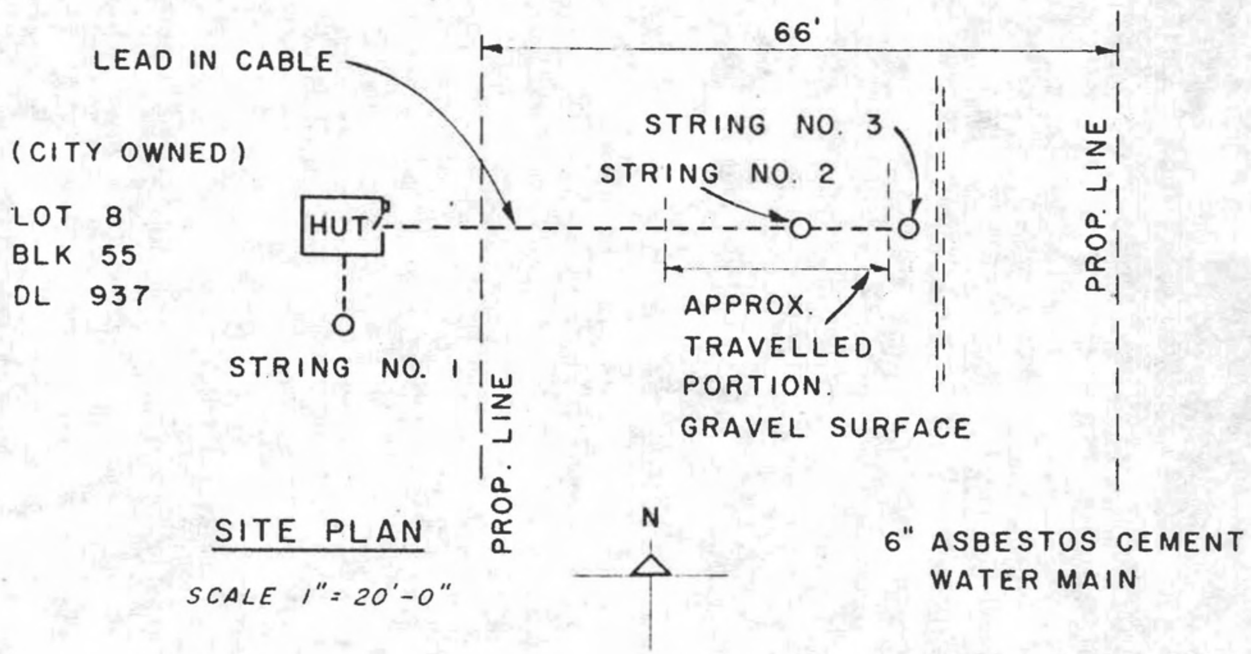
APPENDIX

Temp. - Millivolt Conversion - Copper-Constantan Thermocouples 1938 Calibration

Temp. °F	Mv.	Temp. °F	Mv.
10	-.465	35	+.064
11	-.444	36	+.085
12	-.423	37	+.107
13	-.402	38	+.129
14	-.381	39	+.150
15	-.360	40	+.172
16	-.340	41	+.193
17	-.319	42	+.216
18	-.298	43	+.238
19	-.277	44	+.260
20	-.256	45	+.281
21	-.235	46	+.303
22	-.214	47	+.325
23	-.193	48	+.347
24	-.171	49	+.369
25	-.150	50	+.390
26	-.128	51	+.412
27	-.107	52	+.434
28	-.085	53	+.457
29	-.064	54	+.479
30	-.043	55	+.500
31	-.021	56	+.523
32	-.000	57	+.545
33	+.022	58	+.567
34	+.043	59	+.589
		60	+.612



PROFILES OF THERMOCOUPLE STRINGS



SITE PLAN

SCALE 1" = 20'-0"

FIGURE 1

SOIL TEMPERATURE MEASUREMENT AT CENTRAL STATION

TRACED FROM CITY OF PRINCE GEORGE ENGINEERING DEPT. PLAN 638

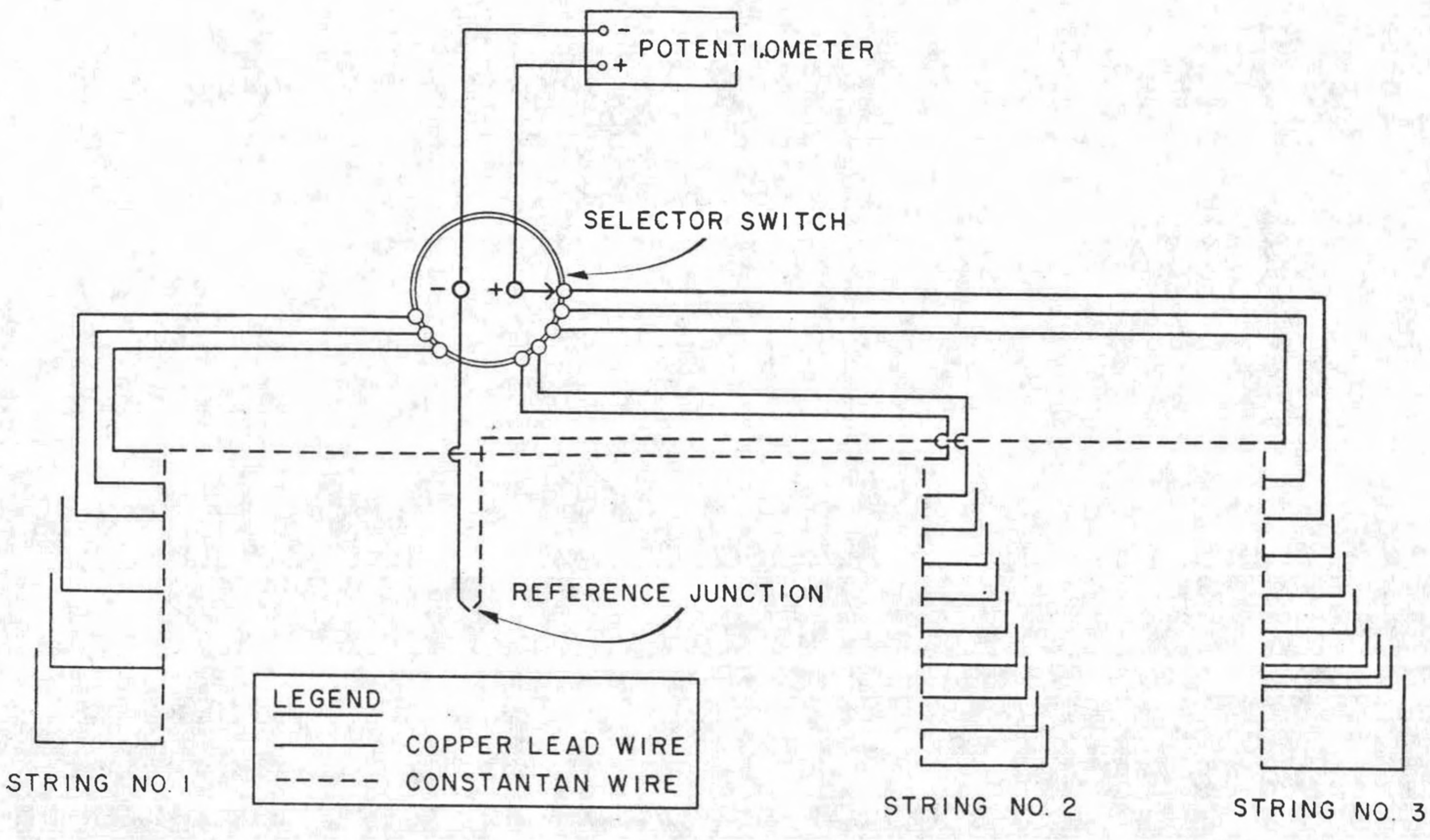


FIGURE 2 CIRCUIT DIAGRAM