Ground Temperature Installations, Powerhouse Extension, Inuvik, N.W.T.

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TECHNICAL NOTE

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PREPARED FOR Northern Canada Power Commission

SUBJECT GROUND TEMPERATURE INSTALLATIONS, POWERHOUSE EXTENSION, INUVIK, N. W. T.

A cooperative study of the duct-ventilated foundation of the extension to the Inuvik, N. W. T. powerhouse has been undertaken by the Division of Building Research, National Research Council of Canada and the Northern Canada Power Commission. This Note has been prepared to record pertinent details of thermocouple cables installed to measure ground temperatures under this foundation.

The main Inuvik powerhouse was constructed in 1958 and is supported on wood piles placed to depths of 25 to 30 ft. An air space, varying from 2 to 8 ft has been maintained between the underside of the insulated floor of the building and the ground surface to dissipate any heat loss from the structure and thus prevent degradation of the permafrost. The rapid growth of Inuvik necessitated installation of additional generating capacity; an extension to house this new equipment was constructed in 1967.

For various reasons (beyond the scope of this Note) the foundation design selected for the extension was different from that used for the existing building. Basically it consists of a concrete slab floor (and concrete generator block) placed on compacted sand and gravel fill. The concrete slab is separated from the fill by a 12-in. layer of "FOAMGLAS" rigid type insulation. The main feature of the foundation, however, is a duct system (9-in. O D steel pipes placed at 2 ft 0 in. O C) buried in the base of the fill and joined by headers (3-ft diam. steel pipe) at each end, through which cold air is circulated during the winter months. The system is closed during the period when air temperatures rise above 30°F. The foundation for the powerhouse extension was completed in late August 1967, and the superstructure in October of the same year.

It was considered essential that the ground thermal regime be closely monitored because of the vital nature of the powerhouse. Using thermocouple installations ground temperature observations have been made at fairly regular intervals under the main building since its construction in 1958 (see DBR/NRC Technical Note No. 472, July 1966). No adverse effects on the ground thermal regime have been noted; the foundation has performed as anticipated. It was considered essential that similar ground temperature observations be made under the extension.

Three thermocouple cables (Nos. 1, 3 and 5) were fabricated by DBR/NRC in January 1967 and were installed by Northern Canada Power Commission personnel at the site of the powerhouse extension in mid-February 1967. Three additional thermocouple cables (Nos. 2, 4 and 6) were fabricated by NCPC personnel (at DBR/NRC) in late May and installed at the site on 13 June 1967, immediately prior to construction. An unprotected thermistor cable (fabrication details not known) provided by the Inuvik Research Laboratory was installed in a drill hole at the site early in January 1967 but was destroyed during construction.

In November 1967 cables Nos. 1, 2, 3 and 5 were connected by DBR/NRC to a main switchboard located inside the extension and ground temperature observations were begun immediately. The leads for cable No. 4 were not located in the gravel fill until the summer of 1968; the cable itself was connected by DBR/NRC to the switchboard in October 1968. The leads for cable No. 6 could not be located. In October 1968, two thermocouple junctions were placed inside each of the main inlet and outlet ducts to measure air temperatures at these points.

FABRICATION OF THERMOCOUPLE CABLES

Each of the six thermocouple cables consisted of twelve 20-gauge, PVC-covered copper-constantan duplex wires of varying lengths. These were taped together so that ground temperatures could be measured at

12 different depths over a total depth of 30 ft. Each of the three cables (Nos. 1, 3 and 5), fabricated by DBR/NRC in January 1967, had a lead length of 40 ft, i.e., a total cable length of 70 ft. Of the three additional cables fabricated in May 1967 by NCPC personnel at DBR, two (Nos. 2 and 4) had lead lengths of 50 ft and one (No. 6) a lead length of 22 ft i.e., total lengths of 80 and 52 ft respectively.

Each group of 12 duplex wires that made up a cable was placed inside a protective 3/4-in. diam. black plastic pipe which was filled with Voltesso 35 transformer oil and tightly plugged at both ends for shipment. The location of the zero point or top thermocouple junction in the cable was marked on the outside of the pipe with masking tape.

INSTALLATION OF THERMOCOUPLE CABLES

Cables Nos. 1, 3 and 5 were installed by the NCPC in February 1967 in 4- to 5-in. diam. holes drilled by a Failing "shot-hole" rig. Each cable was placed in its hole so that the zero mark was at the existing ground surface. The holes were then backfilled with sand and material that had been removed from the hole during drilling.

Cables Nos. 2, 4 and 6 were installed by the NCPC on 13 June 1967 also in 4- to 5-in. drilled holes. Each of these cables was positioned in its hole so that the zero mark coincided with elevation 45.2 ft, i.e., the top of the compacted sand layer in which the 9-in. diam. steel pipes were bedded.

When the 9-in. diam. ducts were in position and the sand layer placed, all cable leads were buried just below the surface of the sand and were brought out to the north side of the building between the ducts.

Pertinent details including the location of the cables and the position of the thermocouple junctions, are given in Table 1 and in Figures 1 and 2. It should be noted that the depths listed in Table 1 were measured from the top of the layer of insulation i.e., Elevation 46.5 (underside of generator block). Approximate ground surface elevations at each cable location are given in Table II.

Although the leads for cable No. 6 could not be located and it was therefore abandoned, details of this cable have been included for information and record purposes.

FINAL CONNECTIONS

In July 1967 cable No. 5 was temporarily connected to a switch; final connection could not be made until early November because of site construction activity. At that time cables Nos. 1, 2, 3 and 5 were connected to a main switchboard inside the building.

It was necessary to extend the leads for these cables so a length of 12-pair, multi-conductor, copper-constantan, thermocouple extension cable (Shaw Flexible Tubes type M-TX-1820-01250) was spliced to each of these ground temperature cables. The individual conductors in the extension cable are of standard grade copper and constantan and are covered with polyvinyl chloride. The bundle of conductors is wrapped with aluminum-backed MYLAR tape and the cable is finished with an over-all jacket of polyvinyl chloride.

The ends of ground temperature cables Nos. 1, 2 and 3 emerged from the gravel fill at the west end of the north wall. Varying lengths were cut from these cables so that the splice could be made 3 to 4 ft above the top of the fill. The length of extension cable (50 ft) used for each of these installations was placed inside an appropriate length of 1/2-in. diam. black polyethylene pipe. Short lengths (2 to 3 ft) of 3/4-in. and 1-in. diam. polyethylene pipe were slipped over this protective tubing before splices were made.

The splice was made by twisting and soldering matching copper wires together and taping each connection separately. The 12 constantan wires from the extension and ground cables were bundled together, tightly wrapped and tied with a length of constantan wire wound round the bundle, and then securely taped.

When the splice was completed, the 1-in. diam. pipe sleeve was pulled over the splice and over the end of the 3/4-in. protective pipe covering the ground cable, and was then tightly clamped in place with an approximate 6-in. overlap. One end of the 3/4-in. pipe sleeve was then inserted into the opposite end of the 1-in. diam. sleeve and tightly clamped. The other end of the 3/4-in. diam. sleeve covered the 1/2-in. diam. extension cable protective pipe and was securely clamped. A weather-proof enclosure for the splice was thus provided. The three extension leads for these cables were then led into the building through a length (about 30 ft) of standard 2-in. electrical conduit, which was tacked to the outside sheathing.

The splice for ground cable No. 5, which was located near the east end of the north wall, was identical to that described previously. The multi-conductor extension lead (33 ft long for this cable), enclosed in a 1/2-in diam. plastic pipe, was tacked temporarily to the exterior sheathing and led into the building through a hole cut in the wall. The cable was then connected to the switchboard. The 1/2-in. plastic pipe was removed in October 1968 and the lead cable placed inside a 1-in. diam. electrical conduit from a point approximately 1 ft below the surface of the gravel fill around the building.

When No. 4 was connected to the switchboard in October 1968 one thermocouple junction (switch point 4) was found to be dead; the leads for this cable did not have to be extended. The 3/4-in. protective plastic pipe in which the cable was originally enclosed was cut off at the surface of the gravel fill and the exposed duplex thermocouple wires were then threaded through a length of 1-in.diam. electrical conduit into the building. The conduit extended approximately 2 ft below the surface of the fill; almost 2 ft of the conduit overlapped the 3/4-in. diam. plastic pipe thus protecting the remainder of the cable.

Two duplex thermocouple wires were placed inside each inlet and outlet main duct to measure the temperature of the air entering and leaving the system. These wires were inserted through 3/8-in. diam. holes drilled in the side of the vertical ducts about 6 inches below the top of the gravel fill. The thermocouple sensing elements were positioned inside the ducts so that temperatures will be measured at the approximate centre of the junction of the 3-ft diam. vertical and main header pipes.

The two duplex wires from the inlet duct were enclosed in 1/2-in. diam. plastic pipe and buried from the hole in the side of the duct to the end of the 1-in. diam. conduit containing cable No. 5, (about 3 ft). The wires entered the building through this 1-in. diam. conduit. The two duplex wires from the outlet duct were enclosed in 1/2-in. diam. plastic pipe and buried from the duct to the wooden shelter protecting the splices for cables Nos. 1, 2 and 3. The two duplex wires were then taped to the outside of the 2-in. diam. conduit, containing cables Nos. 1, 2 and 3, from the shelter to the point where the conduit enters the building.

Each of the 5 ground temperature cables was connected to a Leeds and Northrup 12-point rotary switch mounted on a heavy plywood box located inside the building. The copper wires from each cable were soldered to lugs on the appropriate switch. Each of the 5 cable switches was then connected to a main selector switch (points 1 to 5) which was joined by a common copper wire to a special wire-wound connector to which the reading instrument can be attached. The 4 coppers from the duct duplex wires were connected directly to appropriate terminals (7 to 10) on the main selector switch. All constantans from each ground temperature cable and the duct temperature duplex wires were clamped to the common constantan from the wire-wound connector by a Marr-type constantan connector.

Switching details for each cable are given in Table 1 and a circuit diagram for the switchboard is shown in Figure 3. Ambient air temperatures on the north (duct) side of the extension are measured by a standard mercury thermometer. Ground temperature observations are to be made every two weeks.

TABLE I

INUVIK POWERHOUSE EXTENSION
GROUND TEMPERATURE INSTALLATIONS

THERMOCOUPLE JUNCTION DEPTHS

Cable	1		2		3		4		5		6	
Switch Point	Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.
0	1.5	45.0	1.5	45.0	1.5	45.0	1.5	45.0	1.5	45.0	1.5	45.0
1	2.8	43.7	3.8	42.7	3.0	43.5	3.8	42.7	2.5	44.0	3.8	42.7
2	5.3	41.2	6.3	40.2	5.5	41.0	6.3	40.2	5.0	41.5	6.3	40.2
3	7.8	38.7	8.8	37.7	8.0	38.5	8.8	37.7	7.5	39.0	8.8	37.7
4	10.3	36.2	11.3	35.2	10.5	36.0	*11.3	*35.2	10.0	36.5	11.3	35.2
5	12.8	33.7	13.8	32.7	13.0	33.5	13.8	32.7	12.5	34.0	13.8	32.7
6	15.3	31.2	16.3	30.2	15.5	31.0	16.3	30.2	15.0	31.5	16.3	30.2
7	17.8	28.7	18.8	27.7	18.0	28.5	18.8	27.7	17.5	29.0	18.8	27.7
8	20.3	26.2	21.3	25.2	20.5	26.0	21.3	25.2	20.0	26.5	21.3	25.2
9	22.8	23.7	23.8	22.7	23.0	23.5	23.8	22.7	22.5	24.0	23.8	22.7
10	25.3	21.2	26.3	20.2	25.5	21.0	26.3	20.2	25.0	21.5	26.3	20.2
11	30.3	16.2	31.3	15.2	30.5	16.0	31.3	15.2	30.0	16.5	31.3	15.2

Notes: Depth - below top of 12" thick Foamglas insulation (Elev. + 46.5')
Elevation - based on low water level of East Channel = 0.0' (1954)
Cables 1, 3, 5 fabricated in January 1967, installed in February 1967
Cables 2, 4, 6 fabricated in May, 1967, installed on June 13, 1967
Cable 6 not located - abandoned. Details included for information and reference only.
*This point not operational.

TABLE II

INUVIK POWERHOUSE EXTENSION

GROUND SURFACE ELEVATIONS[a]

Cable	1	2	3	4	5	6
Original[b] 1954	41.5	42.0	42.6	41.6	41.0	42.0
May 17, 1967[c]	46.2	46.1	46.0	46.2	46.5	46.0

NOTE: Elevations in ft. - approximate - $\pm$ 0.5'.

(a) Elevations based on low water level of East Channel = 0.0' (1954).

(b) From NCPC dwg. No. NCP-10531.

(c) From surveys by NCPC., Inuvik - May 17, 1967.

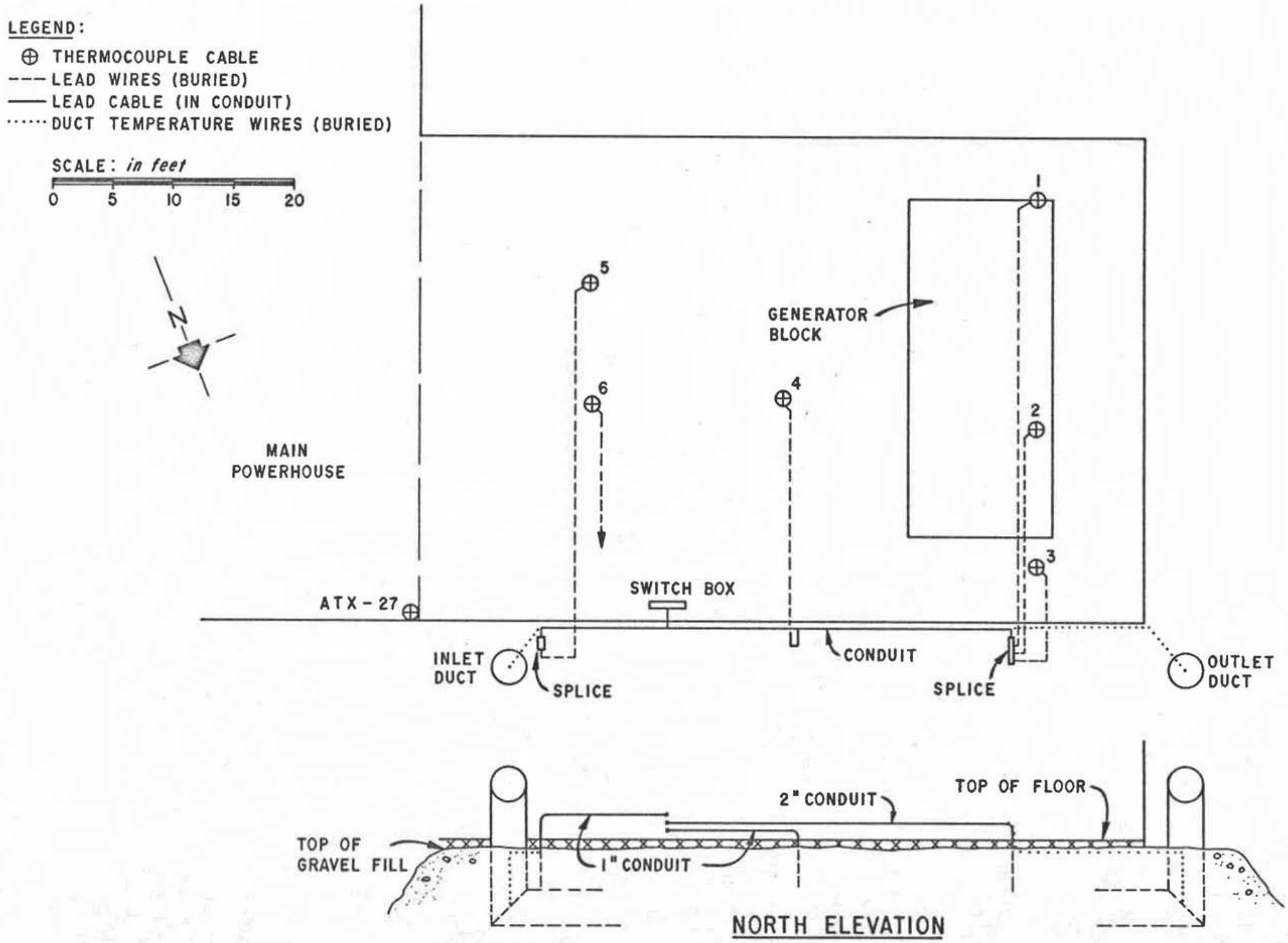


FIGURE 1
INUVIK POWERHOUSE EXTENSION-LOCATION OF THERMOCOUPLE CABLES

BR 4260-1

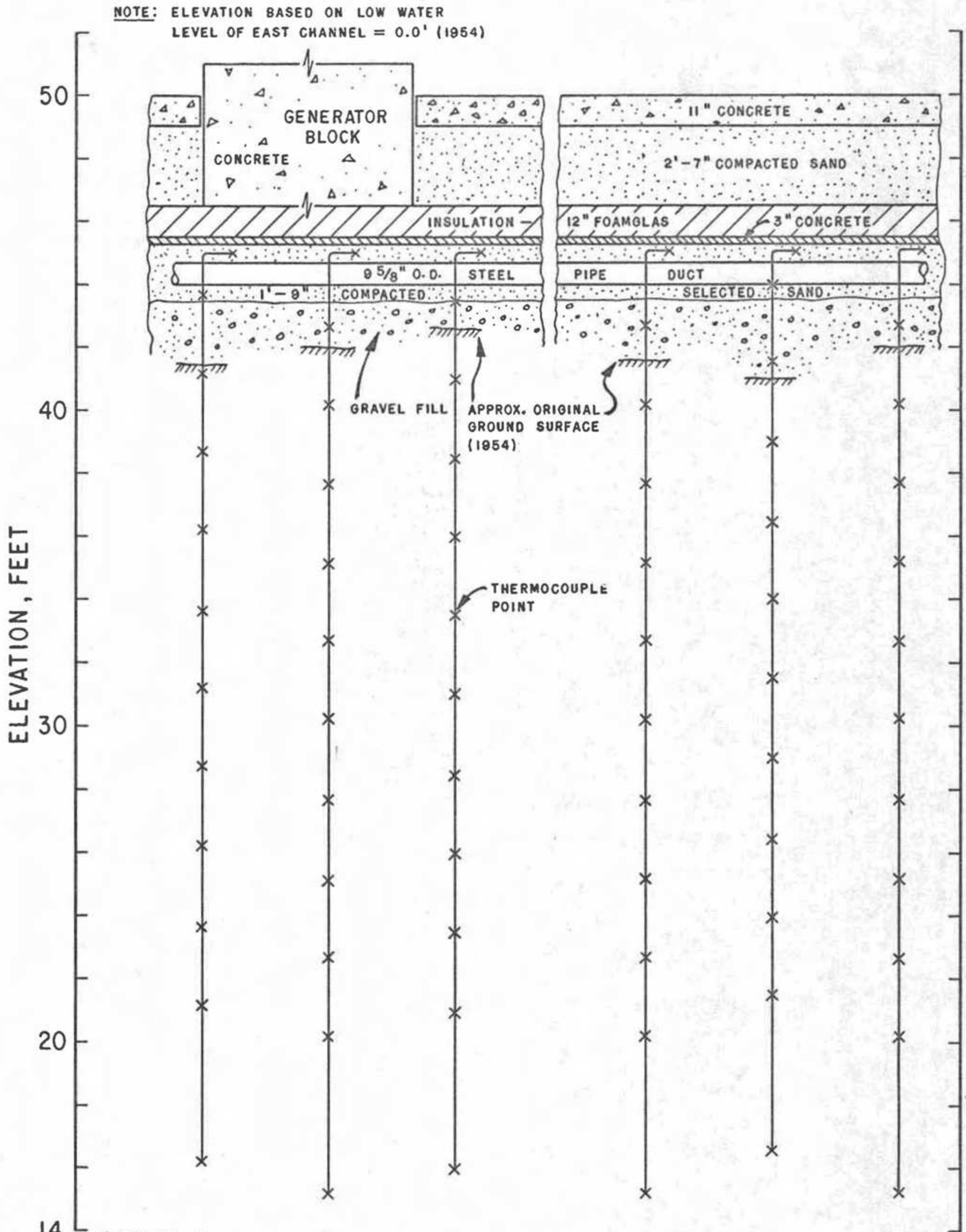
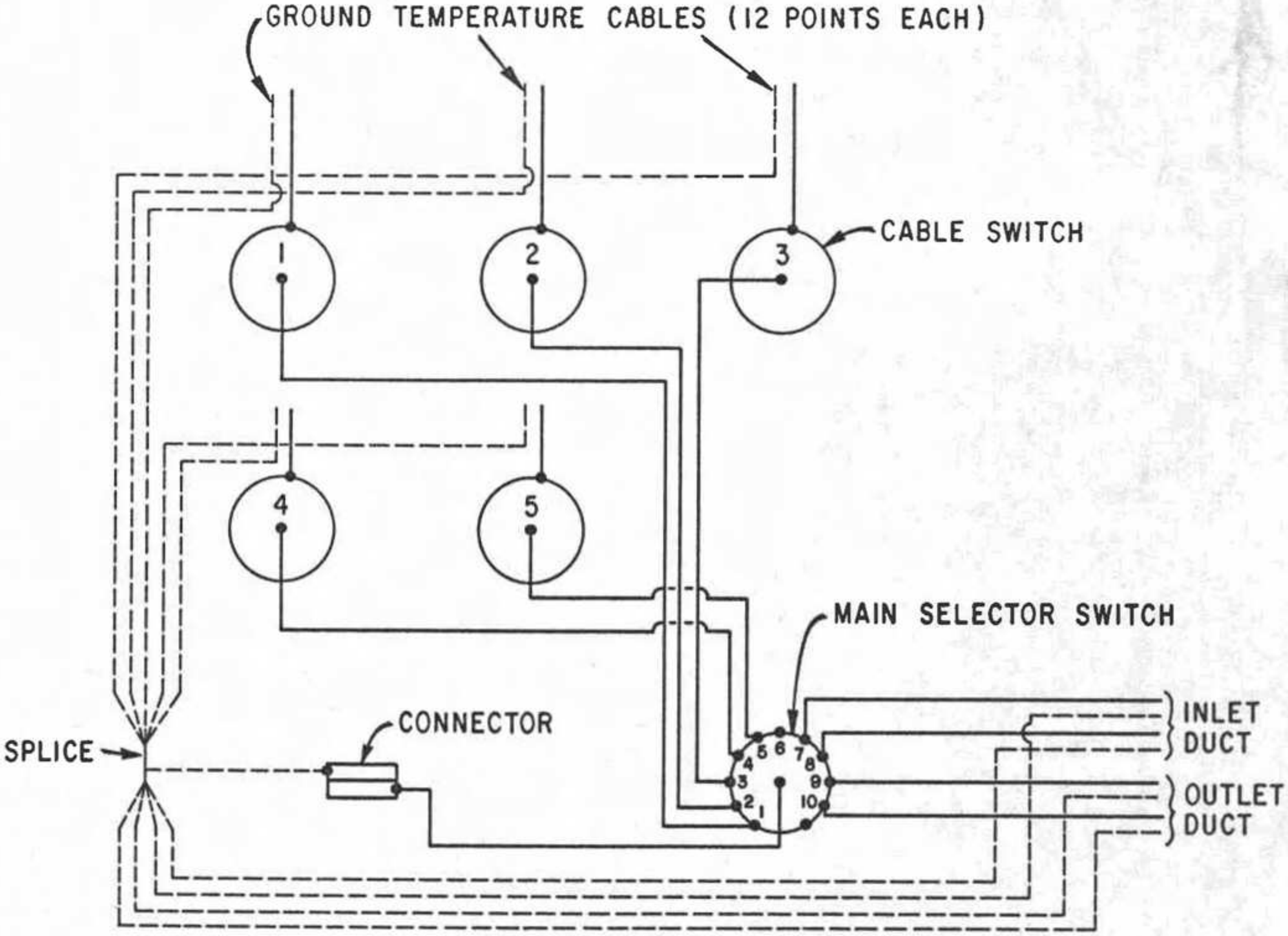


FIGURE 2

INUVIK POWERHOUSE EXTENSION–GROUND TEMPERATURE INSTALLATIONS

BR 4260-2



MAIN SELECTOR SWITCH:

POINT	THERMOCOUPLES
1	CABLE No. 1
2	CABLE No. 2
3	CABLE No. 3
4	CABLE No. 4
5	CABLE No. 5
6	BLANK
7	INLET DUCT
8	INLET DUCT
9	OUTLET DUCT
10	OUTLET DUCT

——— COPPER
- - - - CONSTANTAN

FIGURE 3

CIRCUIT DIAGRAM — MAIN SWITCH BOARD-GROUND TEMPERATURE INSTALLATIONS-POWERHOUSE EXTENSION INUVIK, N.W.T.

BR 4260-3