ground and the severe climate, and also because of the long darkness of twenty hours per day throughout the coldest of the winter months. In the summer, however, the twenty hours of night is changed into day, and during the remaining four or more hours high twilight exists, which gives to the engineer a condition of practically perpetual daylight.

The hillsides are covered with thick moss and a wealth of vegetation, which in places is of almost tropical luxuriance.

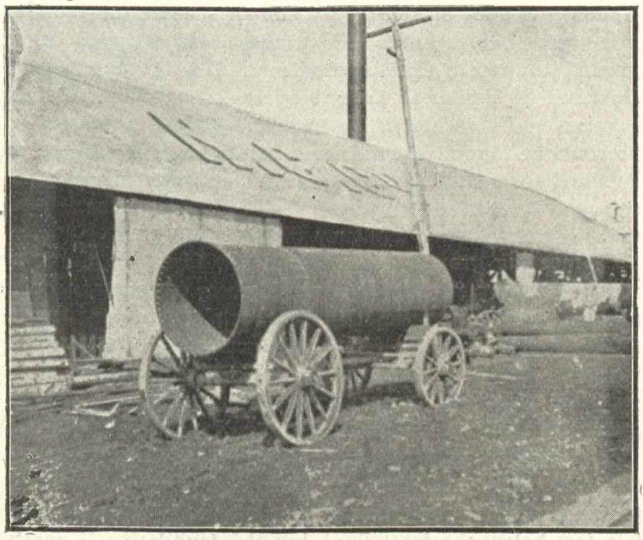

Fig. 4.—Steel Pipe in Dawson City.

Underneath the moss there is usually found a foot or two of thawed soil, beneath which the ground under natural conditions remains frozen throughout all seasons. This condition exists from about the end of May until the end of September or middle of October, and renders any process of excavation uncertain, costly, and frequently dangerous.

In the first place, the ground must be thawed, and, in the case of open channels for conveying water, any mechanical process of softening the ground is too expensive; but if the moss is removed (see Fig. 5) the sun will act on the ground to a depth of six or eight feet, and if the melted water is once drained away the ground will probably not congeal again to the same extent. If possible, therefore, the moss is "stripped" off one summer previous to excavation.

After the thawing is done, if the soil is clean, sharp sand, ordinary steam shovel, scraper or other method of digging may be employed with little or no difficulty.

In case of clay, the usual difficulties in handling are met with, and also the process of thawing is much slower than in sand; but at least it can be said that a ditch in clay is satisfactory when finished.

However, there is another type of soil which, unfortunately, is frequently met with in the Yukon, known as "muck." It is frozen silt and loam, which melts easily, but invariably sloughs away. The difficulty of ditch-cutting in this material is apparent. There is still a worse condition often encountered when muck overlies a glacier and is sometimes part of it. Even if the glacier is surfaced with clay, when the water is turned into the ditch the effect is to honeycomb the ice, and in case of a side-hill excavation, the ground on the lower side is undermined and is in danger of sliding away.

In the map shown as Fig. 1 a considerable portion of the dotted line represents excavated ditch in the water transmission line. The cross-section would average five or six feet deep, seven or eight feet on bottom, with a one, or one and one-half to one slope. The grade is five to eight feet per mile.

The major part of the excavating was done with light steam shovels of Vulcan or Marion No. 20 type, burning wood, which is abundant.

Under best conditions of sand-digging a certain Marion No. 20 shovel averaged in the month of July as high as 100 cubic yards per hour. The entire camp included thirty-six men, working two shifts of ten hours each. The maximum rate of digging was 120 cubic yards per hour. In the month of June the same shovel averaged about 80 cubic yards per hour, the increase being probably due to improved organization of the gang by the foreman.

The operating cost for the month of July was 32 cents per yard, and the corresponding total cost about 50 cents per yard. The cost of handling glacial clay and muck by steam shovel in one case was $1.36 per yard. In another place where steam shovel could not be used the cost of handling by scrapers ran as high as $1.50 per yard. In general, the cost of excavation on work of this nature will probably run from 25 cents to $1.50 per cubic yard. However, it is to be remembered that any statements of cost for the Yukon are only of comparative value in view of the enormous freight rates on imported goods, and also the very high price of labor.

The Flume.

Even the excessive prices of excavation in glacial clay and muck still render the open ditch the cheapest way of conveying water, from a constructional standpoint. However, on account of the dangers of sloughing and honeycombing, it is often necessary to substitute for the ditch a continuous open timber flume (Fig. 3), supported by underpinning. The box is made of 2-inch dressed pine, 5 feet by 7 feet inside, and is designed to carry four feet of water. The details are indicated in the righthand side of the drawing of Fig. 3. It was originally intended to place the bents of underpinning 16 feet apart, but a more careful design placed these on 8-foot centres, according to which most of the flume has been constructed. It is not possible to transmit water through this line during the winter. Consequently, in the fall before the "freeze up" the water is drained out of the entire system. In long sections of flume there are placed "turnouts," constructed according to the design shown in Fig. 4. One is operated simply by closing and opening the proper sluice-gates, whence the water is diverted a few hundred feet and discharged where it will be carried away. The same device is also used as a spillway, preventing the water from overflowing, in event of which the underpinning might be endangered. The question of underpinning will be dealt with under "Foundations."

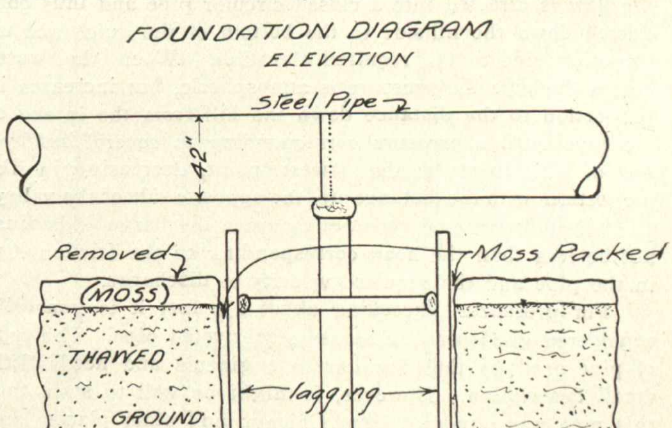

Fig. 5.—Cross-section of Ground and Foundation Diagram.