

Moncton and Winnipeg. Some of these hardly reached their destination before being overtaken by the freeze-up, and were forced to return and cut trails in order to bring up sufficient supplies to carry them over the winter. A transport department was organized, and as soon as the condition of the roads and lakes permitted, large quantities of provisions and outfit were pushed north to the furthest limit of lumbering operations over existing bush roads, and stored in main transport depots, or in warehouses of the Hudson's Bay Co. From these, part of the supplies were forwarded by dog sleigh and packer, and the balance distributed by canoe after the ice had gone out in the following June.

Caches were established from time to time at intervals of from 20 to 40 miles; log shacks were erected and a couple of men placed in charge of each. These were generally located on some canoe route, and being maintained permanently, as long as the surveys lasted, constituted an important aid in their prosecution. Regular systems of mail service were provided later, following the supply routes, but during the long freeze-up, lasting from about the middle of October to the middle of December, and to a less extent throughout the break-up, extending over the greater part of April and May, insecurity of ice on river and lake practically put a stop to communication with the outside world. Throughout most of Quebec and western Ontario, innumerable waterways, many of them rendered navigable for canoes by beavers, provided an easy method of moving camp. But across the interminable muskegs and spruce-covered swamps of the clay belt, parties had in summer to depend solely on the tump line to pack their supplies and outfit.

Medical officers were stationed at wide intervals, but there was little sickness that could not be cured by a blue pill. The most serious discomforts endured were black flies in summer, and a few intensely cold days in midwinter when the mercury sometimes touched 60° below zero. Accidents due to upsetting canoes and breaking through ice were unfortunately, too common. In the first three years of the survey, 27 lives were claimed by the frigid waters of river and lake, at that time the only highways. Narrow escapes were of almost daily occurrence. On several occasions, parties were caught by the freeze-up on their way out, canoes being abandoned, and treacherous river crossings negotiated on hands and knees. Two men tried to run a 30-ft. chute on the Gatineau. One jumped on to a rock, and the other was rescued with difficulty from the pool below after the canoe had been dashed to pieces. Another canoe broke in half while descending the Woodchuck rapids on Bell River, and the occupants paddled five miles into camp seated one in either piece.

GRADES AND ALIGNMENT.

At the outset it was decided that the railway should conform to a high standard. Grades were not to exceed 0.4% opposed to eastbound traffic (which is the heavier), nor 0.6% against westbound traffic. The curvature was limited to 6°, and all curves of 1° and over were connected to their tangents with easy spirals. The 6° limit for curves was used only where topographical conditions prevented easier curves being used at reasonable cost. Grades were compensated for curvature at the rate of 0.4% per degree, so that on 6° curves the maximum grade (eastbound) was 0.16%. Vertical curves were introduced at summits and sags, the rate of change in grade being 0.1% and 0.05%, respectively.

Pusher grades were adopted at two points only and are quite short. The whole line between Moncton and Winnipeg (with the slight exception of short approaches to the Quebec Bridge on 1% grades) was definitely located with the

above mentioned very easy maximum grades. But 146 miles from Moncton, it was found that by the insertion of about 12½ miles of 1.1% grade adverse to eastbound traffic, a saving could be made of 17.2 miles in distance, nearly \$2,000,000 in construction and \$1,250,000 in capitalized operating value. At another point (in Quebec) 286 miles from Moncton, a similar grade 10 miles long, adverse to eastbound traffic, was found to effect a saving of 18.8 miles in distance, about \$500,000 in construction, and over \$750,000 in capitalized operating value. These possibly temporary grades were adopted with the corresponding saving in distance and cost. If the future traffic of the road justifies the expense, these two short links of standard grade can be built at any time.

In comparing rival routes, values based on assumed capitalized cost of maintenance and operation were given to savings in distance, curvature, and rise and fall as noted above. Owing to the locality traversed, artificial values for these, due to competition, seldom had to be considered. Distance was evaluated at \$6 to \$35 per ft., depending on amount saved and expected traffic; curvature at \$48 to \$80 (or more) per degree; and rise and fall at \$36 to \$700 per ft. on long maximum grades requiring the application of brakes in descending.

Throughout the 1800 miles between Moncton and Winnipeg the geographical characteristics, and consequently the engineering problems, varied greatly. The short route across the broken topography of New Brunswick necessitated long stretches of maximum grade and development for distance, culminating on the slopes of the divide between the Miramichi and St. John Rivers. Even with a short pusher grade of 1.1% eventually adopted here, cost of construction was very heavy. This included a tunnel and 3918 ft. of viaduct, 193 ft. high, over the Little Salmon River. A pusher grade was also required to negotiate the summit between the St. Lawrence and Bay of Fundy waters, near the extreme northern corner of Maine. In southern Quebec, the line parallels the St. Lawrence River, 20 miles inland, before swinging north to where the substructure for the new Quebec Bridge is rapidly nearing completion. Just beyond, another great viaduct, 3000 ft. long and over 160 ft. high, was required to span the gulch of Cap Rouge. Three of the piers for this was sunk by pneumatic caisson, one to a depth of 55 ft. below high water.

LOCATION AND ROUTE NORTH OF THE ST. LAWRENCE.

Perhaps the most difficult problem confronting the locating engineers, on the whole eastern division, was to find a path through the forbidding range of hills loosely called the Laurentian Mountains, which forms the northern watershed of the St. Lawrence River. Some 80 miles west of Quebec city this range is abruptly cleft, enabling the St. Maurice River to carry south the accumulated drainage of 15,000 sq. miles. Three alternatives were proposed: 1, to develop a line up one of the more easterly streams until sufficient altitude should be attained to cross over into the St. Maurice valley and follow this to its upper waters; 2, to enter this valley at its lower end, cross it, and attempt to reach the hinterland by way of the Mattawin or Rivière aux Rats, two of its main tributaries from the west, or 3, to proceed further up the St. Lawrence, and pierce the Laurentian at some more westerly point, avoiding the precipitous cliffs of the St. Maurice.

All of these routes were explored. The third, apart from other objections, proved too long. The second and most direct was reported against on account of the excessive slope in the lower waters of the valleys explored, the difficulty of developing distance within their narrow confines, and the great cost of bridging

the lower St. Maurice. The approved route followed up the rivers Batiscan and Brochet, until a pass was reached over-looking the hamlet of La Tuque, at the head of navigation on the St. Maurice, where the latter turns from south-east to south. The descent was effected by fitting a two-mile horseshoe curve into a recession of the hillside.

Beyond La Tuque, the waters of the St. Maurice come down 80 miles from the old Hudson's Bay post at Weymontachene, dropping 700 ft. in a series of cataracts and turbulent rapids. Its course is fairly direct, except for a long detour to the north around the 16 miles of air line between the mouth of the Vermillion and CooCoo Cache. Four miles above La Tuque, the main river is bridged by six 140-ft. trusses, on concrete piers and the precipitous side hill is followed to Vermillion. Here, after repeated efforts, a circuitous route through the long granite ridge was located in CooCoo Cache, and the St. Maurice again followed to Weymontachene.

From Weymontachene to the Gatineau River, the obvious route appeared to be via the Ribbon River, but a 10-mile saving in distance was effected across from its mouth to its upper basin. However, this involved two semi-loops, a 100,000 yd. summit cut and several others of slightly less magnitude. The first preliminary west of the Ribbon struck far to the north, via Haircutting Lake, avoiding the Gatineau valley altogether. Later the east branch of this was crossed and the sinuous line between interlacing waters of the St. Maurice and Gatineau roughly followed to where it intersects the height of land, 50 miles beyond.

Innumerable lakes and creek expansions, separated by irregular ridges of sand and boulders, covered with jack-pine, here constitute the outstanding features of the topography. So intricately interwoven are these, that the country had to be criss-crossed with lines for a width of 20 miles before a satisfactory alignment could be obtained, with a profile showing only moderately heavy work. Similar conditions prevailed for a further distance of 25 miles to the Atik River, which was followed to its junction with the Megiskan, a branch of the great Nottaway. This region was the most inaccessible and least known on the whole line, and will be the last to be completed.

While the St. Maurice valley was being explored from the Quebec end, engineers sent north from Ottawa, North Bay and western points, had made the unexpected discovery that the country beyond the height of land presented far fewer difficulties than that draining into the St. Lawrence. Accordingly, late in 1905 the route south of Lake Abitibi was abandoned.

The actual height of land is crossed three times in northern Quebec, and twice in northern Ontario, with elevations above mean tidewater of 1500, 1070, 1075, 1120 and 1260, respectively. At all of these points except the most westerly, the work is light. From the Megiskan River to Lake Nipigon, occurs a vast spruce-covered plain, of which the soil is a deep agricultural clay, interspersed with a few sand ridges and isolated outcrops of rock, and covered in many places by from 1 to 10 ft. of muskeg. That part east of Lake Abitibi (a shallow and muddy expansion of the Abitibi River, 400 sq. miles in extent) is intersected by the sluggish waters at the sources of the Nottaway and Harricaw Rivers. The western portion, on the other hand, is drained by swift flowing branches of the Moose and Albany Rivers, so numerous as to require a bridge on an average every sixth mile, not counting arch culverts up to 30 ft. span. These show on the profile as deep gulches, separated (except for an occasional long shallow cut) by mile after