

mile of surface line within a few feet of subgrade.

The alignment throughout this section is exceptionally direct. For 250 miles westerly from Lake Abitibi, the length of preliminary location exceeded the air line by less than 4%; it contained only six curves of 3° and none over 3°. The first G.T.P.R. reconnaissance, run in 1903, between the Kenogami and Missinabi Rivers, was a straight line 115 miles long. On final location some of the very long tangents were broken up to obtain more favorable river crossings, but several stretches of 16 to 18 miles were retained.

North of Lake Nipigon, granite ridges alternate with flat stretches of muskeg and clay. These latter occur with decreasing frequency as the line crosses the height of land for the last time to enter the rock-ribbed and unproductive wilderness which forms the barrier separating the farm lands of eastern Canada from the prairies. With the exception of a short tract of indifferent agricultural soil, between Lost Lake and the Wabigoon River, the country is barren and desolate, much of it having been denuded even of its original growth of stunted spruce.

An enormous number of irregular bodies of water lie scattered over its surface, many of them with shores deeply indented, and buttressed by rugged cliffs. In the vicinity of Onamakawash Lake, along Canyon Lake, and on both sides of the Winnipeg River, the rock cuts were exceptionally heavy. Embankments of even larger size had also to be made of rock borrow and train-hauled material. Corresponding conditions prevail along the line of the C.P.R., and repeated surveys showed that no improvement could be effected by adopting a still more northerly route. The last 50 miles into Winnipeg is, for the most part, through settled prairie country. By crossing and keeping south of the C.P.R., the worst portion of the deep Julius muskeg, which required years to fill, was avoided.

CONSTRUCTION WORK.

Actual construction began in the spring of 1906, contracts having been signed for the building of 150 miles from Quebec west, and 245 miles from Winnipeg east. The latter portion was to a connection with the branch to Fort William (then under construction by the G.T.P.R.); thus giving a line from the wheat district to Lake Superior. From time to time additional sections were let, until by October, 1908, the whole line was under contract. Supplies for constructing the most easterly 850 miles were distributed from various points on the Intercolonial, Canadian Northern C.P.R. and other railways. The extreme western end was also easily accessible by steamer and short winter road from various points on the C.P.R. as far east as Dinorwic. The central portion was opened up east and west from La Tuque, the Timiskaming and Northern Ontario Ry., Lake Nipigon, and the Thunder Bay branch of the G.T. Pacific Ry.

Steel on the Quebec and Lake St. John branch was laid into La Tuque early in 1907. About the same time the T. & N. O. Ry. ran its first train into McDougall's Chutes at the head of navigation on the Black River, a tributary of the Abitibi. From here, two main transport routes were established. One extended upstream into Abitibi Lake. The other followed down the Black and Abitibi Rivers, to where the new line crossed the latter, beyond which a monorail tramway was constructed 8 miles across country to the Frederickhouse River. The tramway was operated by a platform truck having shafts attached to a pole at right angles to the rail. The horse thus walked alongside the car and rail, the car being guided on the rail by double-flanged wheels. A service of steamers and gasoline boats was established on each route, short stretches of light-rail tramway be-

ing built around the worst rapids. Push roads were also cut to provide winter communication. Later, when the T. & N. O. Ry. had extended its line 40 miles to a junction with the National Transcontinental Ry. (where the town of Cochrane now stands), the steel was laid east and west over the new grade, these routes were abandoned.

Meanwhile the G.T. Pacific Ry. had finished its branch from Fort William to Sioux Lookout, with a spur into Sturgeon Lake. This extended the field of operations, and gave impetus to that part required to connect Winnipeg with the Great Lakes. In the summer of 1908, a narrow gauge railway, 18 miles long, was constructed around the rapids of the Nipigon River, and before navigation closed that year, a considerable quantity of supplies had been distributed along the north shore of Lake Nipigon by steamers built for the purpose. In the following year an attempt was made to establish a similar transport route from Jackfish over the height of land, into Long Lake, and thence down the Kenogami River. This failed, owing to the inability to secure reasonable grades up the steep ascent from Lake Superior, except at prohibitive cost.

It was accordingly decided that the 350 miles between Cochrane and Lake Nipigon should be covered from either end. By Dec. 1910, 40 miles at the west end of this was graded and track laid for over 100 miles at the Cochrane end. Two months later a winter tote road was completed across the remaining distance, and sufficient supplies and outfit to grade all but a few cuts were distributed in log warehouses erected at intervals of about 20 miles.

GRADING.

As most of the work was of the lightest description, chiefly side casting, the construction plant consisted almost entirely of shovels and wheelbarrows, with a few tons of light rails, some car wheels and a load or two of explosives for loosening frozen clay, and breaking up boulders. This light work was practically finished by Oct., 1911, and up to the end of Feb., 1912, 20% of the balance of the excavation had been completed.

In the heavy rock districts work, of course, proceeded much more slowly. The usual methods of blasting were employed: 1, block holing, loading with dynamite and firing with time fuse, in the smaller cuts; 2, heavy springing, loading partly with black powder and discharging with battery in the larger cuts, or where it was desired to break up and waste several thousand cubic yards at once; 3, tunnel blasting, or "coyoting." For this latter work, the station man was usual paid per lineal foot for shafts and tunnels. In loading these, the high explosives were sometimes left in the case, but the blast was usually more effective if the cartridges were removed from the boxes. Frequently 6000 cu. yd. or more of rock were broken up by one of these blasts. Where the expense of bringing in cars and track was excessive, the shattered rock or muck was removed by stone boat on pole track, the poles being well iced in winter, or lubricated with black oil in summer.

Deep clay cuts in the Abitibi region were excavated with less expense in winter, as in summer horses could only travel in the greasy blue gumbo after the cuts (and often the fills as well) had been corduroyed. But in the winter, so long as the work progressed steadily, even in the coldest weather, the cut did not get time to freeze deeply in a single night, and the frozen top could be undermined or broken down with a few sticks of dynamite. A slight additional expense was incurred in winter by shovelling snow away from the base of the dump.

Much of the grading in New Brunswick and Quebec was performed with steam shovels having dippers of ½ yd. to 2½ yd. capacity. These were hauled

into the work in winter with their necessary complement of dinky engines, cars and track. Some of the smaller machines were similarly used in northern Ontario. Scrapers, both wheel and slush, were employed on the prairie section, and elsewhere generally for light sandy work, a few being sent in across Lake Nipigon. An elevating grader was tried in the Abitibi country, but was soon discarded, as the horses mired in the sticky clay.

SLIDES.

Slides were numerous throughout the clay belt. These occurred, to some extent, in the sides of cuts, which frequently required a slope of 1 on 2 or even flatter. Much more serious, however, were those which took place under deep fills and behind concrete abutments. At Brule Creek and the Okikodasik and South Rivers, heavy concrete structures on poles were moved bodily out of place, but the shifting from original position was not sufficient to prevent the erection of the steel superstructure after movement had stopped. In some instances it appeared probable that pressure behind the concrete had deflected the piles laterally through the yielding clay; in others, that the slip had occurred on an inclined plane below the level of the foundations.

At the little Mistongo, a long 6-ft concrete arch was built on pile foundation, and the deep gully bridged by a light trestle, from which material excavated in an adjoining cut was dumped. Some of this, in wet weather, simply flowed away in a river of mud. After several slides had occurred, which broke up and buried the culvert, sweeping three or four trestles in succession down the slope, the fill was completed in winter, a large square box culvert of heavy timber being built to replace the arch culvert. With the freshet, the embankment again settled, and a small lake formed on the upstream side, from the middle of which protruded one end of the timber culvert, standing upright. Continuous filling at length brought the embankment up to grade, the water being at first pumped and siphoned over the top, and later carried off through a reinforced concrete pipe built permanently through the bank and having a long extension at the downstream end.

BRIDGES AND CULVERTS.

On completion of the main surveys, small parties were sent over the line with instructions to take soundings where any openings were to be left. A light boring machine was used, by which casing pipe screwed together in sections was forced down through the river bed, and the core broken up with the drill, and removed by means of a rope attached to a short tube with ball valve. At the Manuan River, this machine was set on the ice, and the casing driven by an improvised pile driver, consisting of a section of green birch for hammer, working between leads and operated by transport dogs. When the ice went out the machine was transferred to a raft, and the dogs harnessed to the spokes of a windlass. By this contrivance, pipes were driven through 50 ft. of hard compacted sand.

The treacherous soil of the clay belt was the cause of a great deal of trouble in securing stable foundations, especially when attempting to excavate in mid-stream. A coffer-dam for the main pier of the Abitibi bridge, consisting of 4 ft. of puddle, between an outer row of 12-in. ordinary sheet piling, and an inner row of Wakefield sheet piling, 18 in. wide, failed to prove watertight. Eventually a continuous lining of steel sheet piles was driven around the inside and left in the work. The cofferdam was then partly unwatered, and material squeezed up by the foundation piles excavated with an orange-peel bucket to slightly below the river bed. Concrete for this pier was laid in mid-winter, much of it under