future economical working of railways of this class. The questions usually left to the decision of the maintenance engineer are innumerable. Certainly a great many of the difficulties presented were, in the first place, unavoidable, but, unfortunately, not a few were due to bad location. This, however, was not always the fault of the engineer in charge of location, for frequently it would seem that too little time was afforded for this important part of the work, and during the hurry and excitement with which the work of construction was pushed forward, in the eagerness of the promoters to have the line opened for traffic, many of the more important problems of reconstruction were overlooked. It is evident, however, that no amount of time saved in the original work of locating a railway can compensate for errors that may have a deteriorating effect on its future reconstruction and maintenance.

The Canadian Pacific Railway, stretching as it does from the Atlantic to the Pacific, traverses a territory of a nature

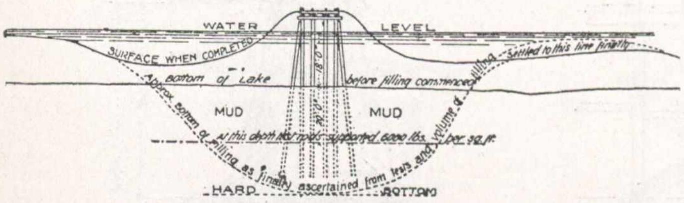

Fig. 1*a*.

so diversified that in its construction nearly every imaginable obstacle was encountered, thus affording a wide field for the ingenuity and skill of its engineers. Notwithstanding the rapidity with which the work of construction was carried on, it is remarkable how few errors were made in dealing with the various obstacles encountered and in providing for the future development of this great project. The experience attained by its engineers has been prolific of much useful data for the benefit of the profession, and has, no doubt, established certain rules to be adhered to in the work of location, peculiar to existing climatic conditions, and applicable to the variable nature of the ground traversed.

For example, in flat country or "table land," it is important that the formation level or subgrade, as it is called, should be kept as high as possible above the average level of the adjoining land, to provide for drainage, and guard against inundations which invariably occur in spring, from the melting of snow on the surface of the hard frozen ground. As the land taken for right-of-way is usually of a uniform width of 99 feet or 6 rods, sufficient material for a single track railway is procured from the side ditches, but failing this the additional filling required is taken from "borrow pits" at convenient points along the line. This class of work is usually termed "cut and cover," a cross section of which is shown Fig. 1b.

In locating over undulating grounds, the material being of a clayey or sliding nature, deep cuttings are avoided as much as possible. Not unfrequently has the removal of a small quantity of material of this peculiar nature caused the general movement of a large area of the adjoining lands. To prevent the cuttings closing in, piling at the foot of slopes had to be resorted to in many cases. In situations of this nature provision is made for draining the roadbed to prevent the track "heaving" while the frost is leaving the ground in spring.

The necessity for a properly drained roadbed in this climate is becoming more apparent now than ever to those interested in the maintenance of permanent way. Many of the recent failures in rails, that have only been in use a short time, can be traced to an uneven, badly drained, and poorly ballasted roadbed.

The location through the mountains was, on account of grade and general contour of the country, confined to a small area, which left little or no means of avoiding places exposed to land slides, snow slides, and wash-outs in spring. The snow sheds, which are an interesting feature of the construction through the mountains, have proved of great benefit in protecting the line from avalanches. Cribwork and masonry retaining walls were also constructed at the foot of slopes as a protection against land slides and erosion by floods.

Temporary Structures.

In preparing the drawings of these structures attention was given to detail as much as possible in order to avoid a lengthy description, and make the work serviceable for reference. The figures illustrate the various structures composed of timber, whether regarded as temporary structures or otherwise. Of course, on a great many American railways timber structures are in many cases considered permanent work, and are renewed from time to time in timber. Indeed, if the durability of such timber as cedar be considered in the construction of box culverts, solid timber open culverts and cattle guards, in favorable situations, it would seem almost unnecessary to employ a more expensive class of structure. In many cases, where cedar had been used on some of the older railways, it was found perfectly sound after thirty years' service. In the case of fence posts and telegraph poles it is invaluable as an exceedingly durable timber, and can be procured at a comparatively small cost. Cedar sleepers or track ties are also used where they are easily procured; but on account of their lightness, and small amount of adhesion to spiking, they have not proved as efficient as those made from tamarac. Cedar is also largely used for piling and substructural work, both above and below water, and no doubt figures prominently in the small cost of maintaining the various structures in question.

Cattle Guards.

Surface cattle guards of various kinds have been introduced indiscriminately, on account of their simplicity and comparative small cost, but so far as the writer is aware they have not proved as efficient as the open timber cattle guard, Figs. 1, 2, and 3. This structure, in some cases, serves also as an open culvert, where the water from the side ditches is intercepted and carried along the public highway. The span is invariably 6 feet and the minimum depth 3 feet. The drawings show the manner in which the structure can be adapted to either cutting or embankment. The sills and side walls are usually made from full squared cedar or tamarac. Cedar sawn on three faces is sometimes used for side walls, with the rough face towards the embankment, and placed on "flatted" cedar sills similar to those shown for box culverts, Figs. 4 and 5. The stringers, ties, and tie cleats are usually of pine.

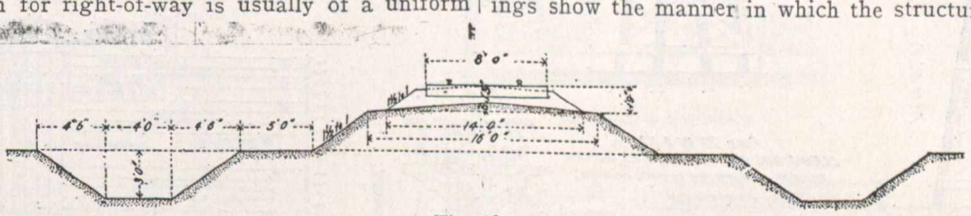
Fig. 1*b*.

Box Culverts.

The cedar box culverts, Figs. 4 and 5, are constructed of 12-inch by 12-inch cedar drift-bolted together, and braced at intervals of about 5 feet with 8-inch by 8-inch cleats bolted to the outside of the side walls. The sills are of "flatted" cedar, 8 inches thick, spaced 5 feet apart, and paved between with rough stone, hand laid. The covers are of 12-inch by 12-inch cedar, checked 1-inch over the side walls, and drift-bolted to the same.

The double 4 feet by 4 feet box culvert, Figs. 6 and 7, is usually constructed where a large waterway is required through an embankment. The number of chambers can be increased to four or six if required. This class of structure