The maximum grade section on the Canadian Pacific is therefore embraced within a distance equal to only 6 per cent. of the main line built by the company, while the maximum grade section of the Union Pacific covers 50 per cent. of its entire distance. And even if the Canadian Pacific maximnm grade section is made to include the section embracing the 66 feet grades, or all above $52\frac{8}{10}$ feet to the mile, it will amount to only 12 per cent. of the main line built by the Company.

Assuming that double the power is required to move a given load over a grade of 116 feet that is required over a grade of 90 feet (and the difference is not nearly so great), it will readily be seen that the advantage is largely in favor of the Canadian Pacific Railway, by reason of its concentration of grades on a short section, and that a given average expenditure of power per mile of railway will move a much greater load over the entire length of the Canadian Pacific Railway than over the Union Pacific; and even if we take for the purpose of comparison a section of the Canadian Pacific extending eastwards from Savona's Ferry 1,032 miles (the Union Pacific distance) and including the heavy grade section, the comparison will still be largely in favor of the Canadian Pacific, whose maximum grade section would be 12 per cent. of the 1032 miles, and the section embracing grades exceeding $52\frac{8}{10}$ feet to the mile less than 24 per cent.; and although such a comparison would be decidedly unfair to the Canadian Pacific, it is clear that the same average expenditure of power would move more tons over this section than over the entire length of the Union Pacific.

A freight train starting from Montreal for the Pacific on the Canadian Pacific Railway will require assistance ascending but one grade, namely, that of the east slope of the Selkirks, and a freight train starting from the Pacific terminus for Montreal will require assistance in only two places; namely, the ascent of the west slope of the Selkirks, and the west slope of the Rocky Mountains; and the two grades coming eastwards are in the direction of the lightest trans-continental traffic.

The line over which the same expenditure of power will move the greatest tonnage is surely the superior line in respect of gradients, and this is governed not so much by the maximum gradients as by their distribution.

A line 100 miles in length with a single gradient of say 150 feet to the mile for five miles is far superior to a line of 100 miles with gradients of fifty feet to the mile, aggregating five miles in length, but scattered along at intervals. In the latter case an average locomotive could haul but twenty loaded cars over the entire line, while on the line with the single heavy grade an average locomotive could haul fifty cars over ninety-five miles of its length, but would require locomotive assistance up the heavy grade of five miles, and even if this assistance should be equivalent to the use of a locomotive for 100 miles on a level line, the advantage of the line with the single heavy grade is obvious, notwithstanding its maximum gradient is three times as great, and no engineer will deny that it is infinitely superior in the matter of gradients to the line with light but scattered grades. This is an extreme case, but it will serve to illustrate the theory upon which the company has proceeded—theory which is stated by an eminent engineer, Mr. Hermann Haupt, in the following words:—

"If the maximum resistances can be concentrated at one point, and overcome at once with the aid of assistant engines, while lighter gradients in favor of the direction of the tonnage prevail on all the rest of the route, the line will be operated cheaply; but if the maximum resistances are scattered over the whole line at intervals more or less remote, the operation will be expensive." And this theory is clearly demonstrated by Mr. Arthur Wellington, C. E., in his treatise "On the economical Theory of the Location of Railways," and is sustained by every modern railway engineer of any standing.

There can be no question as to the practicability of grades of 116 feet to the mile. Such grades may be found on the Baltimore and Ohio and other important American lines carrying a heavy traffic, and the Central Pacific, the most profitable of all the Pacific railways, has many such, combined with curvature up to 12 degrees; and there is no line between the Atlantic and the Pacific on which grades of 116 feet and upwards and curves of 10 degrees and upwards do not occur.

With reference to curvature, I beg to say curves of 10 degrees only occur on the Canadian Pacific between the summit of the Rocky Mountains and the foot of the west slope of the Selkirks, all being embraced within a distance of 115 miles, except for a short distance at Kamloops Lake, and wherever curves and grades occur together, the latter are equated to the curvature. On all the rest of the line built by the Company, the curvature is very easy and it will compare favorably in this respect with any long line on this continent.

Curves of 10 degrees and upwards are not uncommon on some of the very best American Railways. They may be found on such lines as the Pennsylvania, and the Baltimore and Ohio lines running the very fastest trains and carrying the heaviest tonnage of any on this Continent.

In considering the general character of the Canadian Pacific Railway as compared with the Union Pacific, it should be remembered that the former is laid with steel rails throughout, rails weighing 56, 60 and 70 pounds to the yard, while the Union Pacific was laid with 50 pound iron rails.

The embankments of the Canadian Pacific have not in any case been made less than 14 feet in width at formation level, and the earth cuttings 22 feet, while on the Union Pacific they were 12 and 20 feet respectively.

The rock cuttings of the Canadian Pacific