are not made by railway engineers increases their value, for the observations deal largely with the general and mineral resources of the country, which should be controlling factors in the location, but which are often not noted by an engineer absorbed in the study of those details which appear on plan and profile. . . .

It is to be remembered that the great engineering errors in railway location are made in most cases before the instrumental surveys are even started, and that the more widely the preliminary explorations are extended, and the more completely all local sources of information are utilized, the better will the engineer be fitted to deal with the problem that he has been given to solve. The policy now adopted by some Canadian lines of keeping small reconnaisance parties in the field to work up information requisite for future locations is admirable practice, the value of the result being, however, in direct proportion to the character of the men employed, for there is no task that calls for more steady, thorough-going, conscientious hard work than the complete exploration of any piece of country. Exploration should never be regarded as complete until the engineer is able to select the route along which his detail surveys will be made.

When the exploration has been completed, railway location becomes a problem of detail surveying, in which the necessity of reducing first cost to a minimum has to be constantly balanced against the demands of the operating departments for a straight and level track. Surveys with instruments of precision are necessary to adjust the alignment so nicely to the local contour that no stretches of track will be built over which rolling stock cannot be advantageously operated; and the area that can be covered by a precision survey is so limited that nothing but this local adjustment should be expected from it. In making such an adjustment the fact that a railway is simply a great machine for moving traffic must always be kept in mind. It is a machine which has the unique distinction of having two great and often apparently independent parts, the track and the rolling stock; and these are designed by two distinct bodies of men, who have been trained along entirely different lines, and whose views as to the best schemes for future improvement are often antagonistic. The work of the locating engineer will, in most cases, remain unaltered in service for a much longer time than that of his mechanical confrere, and should therefore be designed so that the operating department will always be able to take full advantage of the improvements in rolling stock that are constantly being made. The engineer certainly cannot make this provision without some knowledge of the mechanical principles which control locomotive design and of the developments that may be expected in the immediate future. These developments are usually foreshadowed by the practice of the lines carrying the heaviest traffic, and are thoroughly discussed in the current technical press. . . .

That the most efficient railway is the one whose track and motive power are best adjusted to each other is the lesson of modern operating, but before considering how this adjustment should be made, it will be well to notice the great development in rolling stock that has taken place since the days of the C.P.R. surveys. The specifications of about 1885 called for the use of rolling loads, consisting of engines weighing 110,000 lbs., followed by 3,000 lbs. per lineal foot; those of to-day require engines of 225,000 lbs. followed by 5,000 lbs. per lineal foot. The modern car for heavy ore and coal traffic has a nominal capacity of 100,000 lbs. and a weight of about 36,000 lbs. Remembering that it is not unusual to overload these cars, and that some of them are not above 30 feet in length, it will be seen that the extra heavy specification of to-day is not in advance of the extremes of present practice, and that weights as high as 40,000 lbs. are sometimes concentrated on a single car axle. These ore cars are, however, somewhat exceptional, and for regular freight traffic cars of 60,000 lbs. capacity, with weights slightly over 30,000 lbs., are most common. During an extensive discussion before the New York Railway clubs in November, 1901, Mr. Vauclain stated that a load of 45,000 lbs. per axle might be considered the limit of good locomotive practice at that date, and although in special cases it has been exceeded, there are but few engines in service on the continent to-day with axle loads exceeding 50,000 lbs. In Canadian practice the maximum axle loads vary from 45,000 to 50,000 lbs. on the various roads, the heaviest loadings being found on engines of the 10-wheel and mogul types. In the discussion referred to, the increase of grate area and boiler heating surface were pointed out as being the latest achievements of locomotive engineering.

It has often been stated that the increase of rolling stock weights must very soon cease, and as often the prediction has proved to be entirely wrong. There are some facts that to-day point to at least a temporary suspension in this increase. These are the establishment of a standard box-car, the proven difficulty in economically handling trains more than 70 cars in length, and the difficulty of obtaining satisfactory rail to use under existing rolling stock.

In order to adjust his line so as to permit the easiest train movement, the engineer must thoroughly understand the action of the forces that affect that movement. These forces are locomotive power, momentum, gravity, curve friction and that miscellaneous group known as running resistance, and all of them are variable in amount according to circumstances. (These forces are then treated of in detail).

The safety of using momentum grades in location is one of the disputed points of present practice. Comparing momentum with locomotive tractive power, it may be said that tractive power is directly dependent upon the condition of the engine and the skill of its crew, and will often be much below its calculated value, and that momentum is equally uncertain if the velocity which is essential to its existence is obtained from surplus engine power. Momentum which is obtained by the action of gravity is the most dependable of mechanical forces. The use of momentum grades is universal in operating practice. As a case in point the Lachute example, already referred to may be quoted, or the action of the Grand Trunk Railway in moving Gananoque Junction about 1½ miles eastward in order to place it at the top of a long up-grade, which included a stretch of 50 feet to the mile gradient. The possibilities of using momentum to advantage are greatly limited by topographical conditions. As already remarked, it gives no assistance at the upper end of long grades, and the use of short, sharp grades is limited by the necessity of changing the rate of grade slowly at summit and hollow, which will sometimes altogether prevent their introduction. Its assistance can be gained only at the price of reduced speed, which may be undesirable where fast service is necessary, and there is always an uncertainty as to the continued existence of the conditions which make the required velocity of approach a possibility. The necessary control of speed due to features of the existing track, the demands for new stations and sidings by future industrial development, and the establishment of level road on railway crossings may at any time render momentum operation impossible. During the past year the Railway Committee, in one instance, sanctioned the putting in of a level railway crossing across a line carrying one of the fastest and most important passenger traffics in Canada, and in the very centre of a long grade averaging 35 feet to the mile. This example—the crossing of the Grand Trunk line by the Aurora and Schomberg Railway—indicates very clearly the caution that should be observed in planning momentum grades. When used, they should be introduced as close as possible to the foot of the hill, and there seems no strong objection to rates of grade as steep as the pusher equivalent of the ruling grade. A stalled train cannot be divided into fewer than two parts, and for certainty of operation a doubling siding should be placed at the head of every serious momentum grade. . . .

Concluded in next issue.

—Alex. MacPherson, manager of the Toronto branch of the Canadian Rubber Co. for the past five years, is returning this month to headquarters in Montreal. On the occasion of leaving Toronto a farewell dinner was tendered him by the Wholesale Shoe Association, at McConkey's, as an expression of the esteem in which he has been held by the trade.