longer routes, the receipts will not be affected by changes of distance.

The revenue from through exchange competitive traffic, class 3, may be seriously reduced by shortening the line. The rates on such traffic, as in class 2, are usually established in the case of freight with a more or less disregard of distance, and in the case of passengers by the mileage of the shortest line; but the division of the total between the lines participating in the business is in the proportion of the mileage of each, or on a pro rata per rate basis. It is evident, thereof, that so far as this class of traffic is concerned, if the line be shortened, its proportion of the revenue will be correpondingly decreased. Some lines, on account of physical advantages or for various reasons, may be given "differentials" or "reconstructive mileage," or "arbitraries" for terminal bridge transfer, or other expenses, in addition to their proportion of the remainder of the revenue. To estimate the loss that would result to this class of traffic by shortening the line, we first deduct the amount of the arbitraries from the total yearly revenue for such traffic, and if the receipts are pro-rated on a mileage basis we multiply the balance by the difference between the ratios of the home mileage to the total average mileage before and after the contemplated changes. If the revenue is apportioned on a pro rata per rate basis, this latter multiple is determined accordingly.

Summarizing the foregoing, from classes 1 and 3, it is seen that a direct loss of revenue will result from shortening the line; the revenue from class 2, which at most is but a small proportion of the total, will be affected injuriously or not at all, according as the home line is shorter or longer than its competitors. Thus it might appear that there is no credit side to eliminating distance other than would result from the saving in operating expenses. This, however, is true only of such traffic as has been actually obtained. The shortest line between competitive points is, other things being equal, in much the most advantageous position for securing the largest proportion of the traffic, and anv improvements tending to shorten the longer line will prove decidedly beneficial in that respect, but once the business is secured the advantage is wholly in favor of the long haul.

To the ordinary passenger, time is the first consideration. Distance is largely a technicality which no more concerns him than the grades or curves of the line, and the quickest route to his destination is the most likely to receive his patronage. Whatever the character of the improvements, therefore, whether of the nature of grade and curvature reductions or the elimination of distance, if they are such as will facilitate the running of faster trains, they will tend to increase the volume of traffic, and consequently the revenue.

The exenses of operation will be more or less affected by minor changes in distance which may be necessitated by grade reductions. If the agreements between the company and its employes are not based on mileage, train wages will not usually be subject to modification because of a slight change in the length of the section. Track force and maintenance of way expenses will depend upon the extent of the change.

The following estimates of the effect of slight alterations in distance on operating expenses are based on Wellington's results, and are figured for an average train mile cost of 85 cents. Having determined the actual train mile cost on any particular section, these amounts should be adjusted proportionately.

	If train wages are affected.	If train wages are not affected.
Changes aggregating from 0 to 2 miles ..	33.7c.	21.1c.
Changes aggregating from 2 to 15 miles ..	43.7c.	31.0c.

The above figures, multiplied by the total number of trains each way in a year, give the value of one mile increase or decrease in distance. The number of trains to be used in this calculation will be that operated on the old line, or necessary to handle the same volume of traffic on the new line, according as the length of the section is reduced or increased by the improvements.

At a station at which freight trains may be required to stop for water or other purposes, the engine rating may be materially reduced below what it otherwise would be if at that point a grade at the same rate as the ruling grade were adopted. The rating for the whole section is thus limited to that which the locomotive can start on the ruling grade on which it is necessary to stop. It is the criterion of economical operation that, so far as possible the engine be working with uniformity, and at its full capacity on all parts of a section. Yet instances are to be found, to a greater or less extent on all railways, in which the full power of the locomotive is demanded only at one or two points in an engine stage, where stations have been located on grades which have not been compensated for stopping. The consequent reduction in the rating for the whole section thereby greatly increases the expense of operation, but not usually to such an extent as to warrant the use of assistant engines. The arbitrary method of compensating such grades two-tenths per cent. at stops is, as will be seen from the following, much too little:

Fig. 1 gives, in lbs. per ton, the train resistance curve and the traction power curve of a modern locomotive for speeds from 0 to 10 miles an hour. At the point of starting the resistance is much greater than at 5 or 7 miles an hour, when it reaches a minimum of about 4½ lbs. a ton. The tractive power, on the other hand, remains practically constant between these speed limits. Compound engines, by being thrown into simple, may increase their tractive power at low speeds, and thus possess a reserve force for starting or surmounting short, heavy grades.

With the old form of link couplers trains could be started from rest on much heavier grades than is possible at present with automatic couplers. The slack between the cars was much greater, and the locomotive had acquired a considerable speed before the caboose began to move. The very great starting resistance was thus overcome in the forward part of the train when but a small proportion of the road was being acted upon.

Taking 3 ins. as the average draw bar extension in freight cars, in a train loaded for a 0.5% grade, or say 41 cars, there is 20 ft. slack. In that distance, the engine working under full steam, without its train attached, can acquire a speed of 7.5 miles an hour. In order to simplify the following calculations, we will assume that the full amount of slack is taken up by the engine before the train begins to move, and the momentum thus acquired in the locomotive is transferred to the train instantly, instead of gradually, as is actually the case. The error introduced by this assumption is inappreciable, and is on the right side. The velocity with which the train moves at the instant of starting is given by the momentum equation $130 \times 7.5 = 2018 \times V$, from which V = .48. The level tangent resistance at this speed is 13 lbs. a ton; the engine tractive power at this speed is 15.4 lbs. a ton, from which we deduct 2 lbs. for acceleration, or 13.4 lbs. a ton. The force, therefore, available for overcoming grade resistance is 0.4 lbs. a ton, equivalent to a 0.02% grade.

The distance in which the train on this grade will acquire a speed of 10 miles an hour is determined from the formula deduced for momentum grades, $d = \frac{(V_1 - V_2)\ 2000}{f - 20\ r}$, and