Economics of Railway Improvements.

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The question of the most advantageous methods of improving existing railway lines, and the effect of such improvements upon operating expenses, is one to which the attention of the railway engineer of the present day is frequently directed. The object of this paper is to outline methods by which the most economical results may be obtained in operation, and to define a basis upon which the yearly value of railway improvements may be quickly and accurately estimated ; at the same time to epitomize a vast and varied subject into such brief space as to facilitate its ready application in practice.

The profession of civil engineering has been defined as "the art of making a dollar earn the most interest," a definition which in no branch of the profession should be more closely adhered to as a maxim than in railway engineering. Evidences are to be found on every hand of enterprises in which the financial aspect has been largely lost sight of by engineers who were desirous of building works of monumental excellence rather than of structural utility. The result, in many instances, has been the impoverishment of the company before the line could be equipped for economical operation, or even completed. The promoters of railway projects, on the other hand, in their zeal to reduce first cost, have, in many cases, constructed lines of such a character that the expense of operation has bankrupted enterprises that might otherwise have proved financially successful. Between these extremes there is always a happy mean which will give the largest return for the money invested, and upon the engineer's ability to discover the wisest middle course may depend the success of the venture. Generally speaking, the most economical line to adopt may be defined as that on which the sum of the operating expenses and the interest charges on the total expenditure are least.

Many existing lines, built under limited financial conditions, in the expectation of a sufficiently large traffic in the future to warrant radical improvements, have been greatly handicapped because of the failure of the promoters to recognize the paramount importance of adopting the lowest rate of grade which the country would afford. Unfortunately, engineers are prone to work to the extreme limit of grades and curves, even to the extent of adopting a maximum grade in localities where a minor gradient might as easily have been obtained. The result of such lack of foresight is that any attempt to improve the grades involves practically the reconstruction of the whole line. Until the traffic has developed sufficiently to justify such radical changes the line is operated under most unfavorable conditions, which, in numerous instances, has resulted in the appointment of a receiver. However favorable the conditions under which a line is projected, there is but a small margin for error either during construction or in later improvements. Mistakes in alignment may be rectified, structures rebuilt and local sags removed, but the ruling grade of a line, once established, is the limiting feature which governs largely the expense of operation.

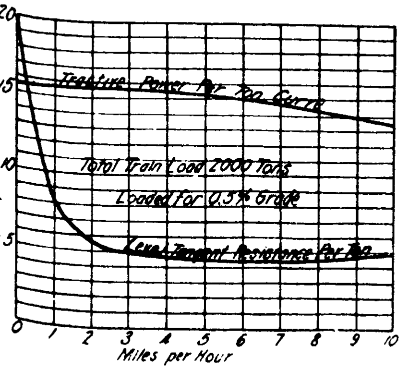

FIGURE 1.

Many lines and particularly transcontinental lines, have largely by their own agencies, developed the traffic which they carry, and with little hope of immediate return have been built in the cheapest possible manner with heavy grades and sharp curvature. Later on, with the development of traffic and the impetus of competition, the line is inadequate to the business, and means must be sought for increasing its facilities. Railways constructed under such conditions should seldom, if ever, be double-tracked without the intermediate step of reducing the grades. This is particularly true of lines with but little more traffic than can be handled economically and expeditiously. The convenience and rapidity with which trains can be operated on a double track line, and the sentimental bias of the public in their favor, have been incentives towards the double-tracking of many lines, when to have reduced the grades would have involved a much less expenditure of money. Viewed from a financial standpoint, the latter course will usually pay a greater percentage of interest on the investment, at the same time facilitating the economical handling of a larger volume of traffic than was previously possible.

In the case of lines with a heavy passenger or suburban traffic, the conditions are quite reversed. The question becomes one rather of the number of light trains which can be operated rapidly and in quick succession, and without danger of delay, than of the number of tons that can be handled in a train. To increase the number of tracks as the business justifies is evidently the solution of the problem.

The cost of double-tracking will seldom be less than 50% of the first cost of construction; and in rough country, where it may be necessary to completely divert the second track, it will more often approach 75%. Rails and fastenings, ties and ballast, will be approximately 100% of the cost of such items in first construction. The cost of grading may vary from 40 to 60% of the first cost, depending upon the topography of the country ; the cost of bridging from 75 to 90%. From this it is evident that the traffic of a line must be very considerable, and greatly congested, if the heavy expenditures thus entailed cannot be postponed for a number of years by a reduction of the grades. As an illustration of the advantages of the latter course, a reduction of a ruling gradient from 1% to 0.4% practically doubles the haulage capacity of locomotives and reduces the number of freight trains about 50%, and the expense of operation about 25%—a course which, on lines with a moderate traffic is usually warranted by the consequent reduction in operating expenses alone, aside from the advantages afforded for handling an increase of business.

Simultaneously with grade reductions, many other improvements may be effected without adding materially to the cost, at the same time placing the line in a fit condition to be double-tracked in the future. At no time is a better opportunity offered for putting in transition ends to curves which have not been previously eased. Objectionable features of alignment may be removed and curvature eliminated. In many cases it will be found possible to consolidate a number of heavy grades in one section, which may then be operated with comparative economy, but which the traffic would not warrant reducing, and thus full benefit may be derived from improvements in adjoining sections. It will usually be found more economical to operate heavy grades in the vicinity of divisional points with the assistance of the yard engines,

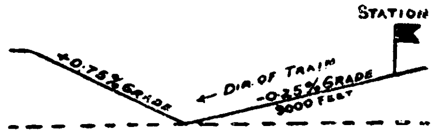

FIG. 2.

reducing the grades on the remainder of the section ; and at points where it would be necessary to construct several miles of new line, to avoid a short heavy grade, it will often be found more economical to double the train.

Little advantage is to be obtained in operation from improvements which are not calculated to increase the engine rating for the whole section. An excessive ruling gradient at one point, the necessity for stopping on a grade, or insufficient compensation for curvature on a ruling gradient, may appreciably limit the rating of the section. In order, therefore, to obtain the most economical results in operation, improvements should be designed to make the rating uniform on all ruling gradients.

The extent to which freight and passenger receipts will be affected by minor changes in distance depends largely upon the nature of the traffic, and upon the geographical position of the line in relation to its competitors. The relative proportions of the different classes of traffic vary greatly on different roads or on different parts of the same road, so that each case must be carefully studied with reference to the peculiar conditions which obtain on that particular section. It is evidently impossible, in a general discussion of the subject, to obtain results which may be applicable in all cases. We may, however, define a basis upon which to proceed intelligently to estimate the effect of such changes upon freight and passenger revenue, as well as upon operating expenses, which latter we are able to determine with considerable accuracy. For this purpose we divide the traffic into three distinct classes. Traffic of any other nature will, so far as this estimate is concerned, be found to belong to one or the other class :

Class 1.—Local and exchange traffic, non-competitive, between points on one line, or passing over two or more lines, but having no option as to route.

Class 2.—Local traffic, competitive, between points on one line, but having an option of two or more routes.

Class 3.—Through exchange traffic, competitive, passing over several lines, with an option of two or more routes.

Non-competitive traffic, class 1, usually represents the major proportion of the total on all roads, and a shortening of the line will at once result in a direct loss of revenue. This loss is proportional to the amount by which the line is shortened, and may be obtained as follows : Multiply the total number of revenue tons and passengers passing over that portion of the line in a year by the average revenue per ton, and per passenger mile, from such traffic, and by the number of miles by which the line is shortened.

The rates on local competitive freight traffic, class 2, are usually arranged on a mileage basis, unless arbitrarily fixed on account of boat or other competition, with a more or less disregard of the actual distance traversed. In the latter case the revenue will be neither increased nor decreased by slight changes in the length of the line. In the case of local competitive passenger traffic, the rates are determined by the mileage of the shortest line. If based on the mileage of the home line, the revenue from this traffic may be materially reduced by shortening the line, which loss may be estimated, as in the case of class 1. If the home line is one of the