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What is the Capacity of a Single Track Railway Line?

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The following paper has been written with a view to reducing to a concrete form, some methods of arriving at what is the capacity of a single track line. It is an attempt to show a means of arriving at the relative value of different elements, which tend to reduce the amount of tonnage that can be hauled in a given time.

A train moving along the track at a given speed has kinetic energy which would raise it vertically a definite number of feet, and every speed has an equivalent vertical height. The relation of speed to the vertical height is expressed by the formula $0.035V^2$, where V is the speed in miles per hour. That is, the kinetic energy of a train running 10 m.p.h., would be capable of raising that train 3.5 ft. If, therefore, ordinates be erected on the engineering profile equal to the vertical height—equivalent to the speed at different points on the road, and the ends of these ordinates are joined up, a second profile, representing the operating conditions of the train, are secured. Such an operation is shown, dotted for westbound, and solid for eastbound, in fig. 1. From this a schedule of the train can be made.

The average speed of a train between any two points may be obtained by finding the area of the figure bounded by the line representing the engineering profile, and the operating, or velocity profile. Dividing this area by the horizontal distance between the two points gives the average velocity height between the two points, which is equivalent to a certain speed in miles per hour. On the profile, fig. 1, the average speed has been worked out between each mile post, and is shown on the bottom margin; below these are the number of minutes it would take the train to run between the two mile posts. Summing up these, the time taken between the passing tracks is noted below each station, that on the right showing the time taken in running from the passing track next to the right, to the station below which the figures show; similarly those to the left denote the running time from the next passing track to the left. An explanation of the process of working out this velocity profile is made at the end of this paper. The reduction in speed due to the application of breaks, is found from the formula,

$$L = \frac{0.035V^2W}{0.7fw\frac{W}{2000}+Rt}$$

L is the distance in which the stop is made; V, the speed in m.p.h.; W, the weight of loaded cars; w, the weight of empty cars; f, the coefficient of friction taken here as 1-6; and Rt, the train resistance per ton.

The amount of tonnage which can be hauled over a single track is dependent on a number of conditions, among which are:—(a) Passing track facilities and train schedules. (b) The tractive effort of the locomotive. (c) Terminal facilities. (d) The ruling grade of the division. (e) The average rate of the grades.

The accompanying train sheets, figs. 2 to 8, develop the principles involved in the laying out of passing tracks on a single track line, and the effect on the train schedules. In drawing them up the same method is used as is employed by the superintendent in making up his schedules, and which is commonly known as "stringing" the trains. The heavy horizontal lines represent passing tracks, the vertical lines denote time; the interval between the passing tracks is measured in the time necessary to run between them, the diagonal lines represent the train movement.

In fig. 2 the passing tracks are equally spaced. The maximum train schedule would then be one where the leaving times of the trains would be twice the passing track interval apart.

Fig. 3 illustrates the effect produced on the north bound trains, by the disregard of the above relation between train schedule and passing track interval. The effect of increasing the interval between the departure times of certain of the southbound trains, is to introduce an element of delay on all northbound trains, which these irregularly spaced trains have to meet, by just the amount of increase in the leaving interval, at every meeting point.

Fig. 4 shows the effect of attempting to run the same number of trains as in fig. 2, when the passing tracks are not all equally spaced. The result would be, that if the southbound trains are superior, the northbound trains could not get through at all.

Fig. 5 indicates the train schedule that would be necessary when passing tracks are unevenly spaced. It is apparent that the interval between the leaving times of the trains would now have to be twice the interval necessary to run between the two passing tracks which are spaced farthest apart, and that in addition delay is introduced at all other passing tracks equal to twice the difference between the closer spaced passing tracks and the greater.

Fig. 6 is the same as the above, except that there is but one irregularly spaced passing track; the law remains the same.

The effect of attempting to run more than the number of trains determined by the passing track intervals, is illustrated in fig. 7, the result being that an element of delay is introduced on the opposing trains equal to the regular schedule leaving interval at every meeting point, almost the amount of time necessary to run two trains over the division.

Fig. 8 shows the effect of introducing trains into the schedule of different speeds. It can be seen from this diagram that trains running 3, 5, 7, 9, etc., times as fast as the others, will eliminate a train in the opposing direction, every 3rd, 5th, 7th, etc., whereas trains running 2, 4, 6, 8, etc., times as fast will eliminate an opposing train every 4th, 8th, 10th, 16th, etc., and delay the intermediate trains by the amount of their leaving interval. The number of trains affected when the multiple of the speed is an odd number will vary inversely as the multiple. The number of trains affected when the multiple of the speed is even, will vary inversely as twice the multiple of the speed, therefore if different speed trains are in service they will produce the least objectionable effect when the speeds differ by an

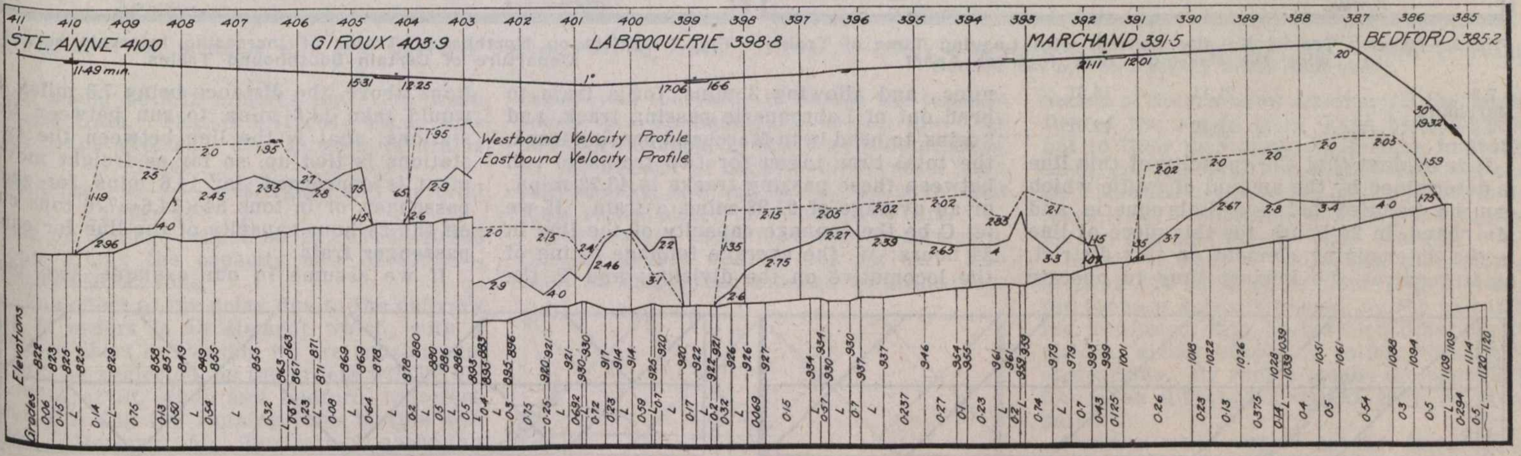

Fig. 1.—Engineering and Velocity Profiles of Line under Discussion.