delay or trouble to the regular operation of the mill. In fact, no greater trouble arose with regard to locating and making the necessary retests than is demanded in any mill when all the top rails of a heat, or even a whole heat, have to be located and identified in order to comply with rejection requirements, a matter of more or less every-day occurrence in some mills.

Undeniably the judging of the fractures produced by the nick and break test is a matter of great importance, and requires the services of experienced and competent men; but so do all the detailed parts of intelligent and efficient rail inspection; in fact, the same statement can be truthfully made in regard to every detail of steel rail making. The trend of all matters pertaining to rails is indisputably toward obtaining a safer and better wearing product, railroad officials and manufacturers alike being more appreciative of conditions in this respect than ever before; this attitude, no doubt, being stimulated because of the activities of the different governmental and state commissions. Recent improvements in mill practice have been acknowledged, and it is equally true that railroads are taking greater pains than formerly with the maintenance of their tracks and equipment, and thus of greatly increased importance is the employment of experienced and competent inspectors with whom to entrust the duties of rail inspection. Any specification and any detail of inspection becomes a hardship to the manufacturer and wasted expenditure to the purchaser when inexperience and incapable inspectors are employed, and under such circumstances the nick and break test specification is of no greater assurance against accepting bad rails than it is against making bad steel.

THE BUILDING AND FINANCING OF SUBWAYS.*

FROM a careful analysis of increase in population in various cities, compared with the increase in street railway patronage, this increase is at a slightly higher rate per year than the square of the increase in population of the territory served.

As a result of the marked increase in patronage in such cities as New York, Philadelphia and Boston, a condition was reached on various highways where it was deemed impossible, or at least uneconomical to further increase the number of street cars per hour. There is some difference of opinion as to the exact point of saturation for surface car service. To analyze in detail this condition requires an assumption as to minimum headway between surface cars. Various estimates show that an interval of nine seconds between moving units on the street is consistent with safety. Assuming this fact and adding to it the estimated period of rest of seven seconds for a car, to permit of passengers boarding and leaving would result in cars passing a certain point at the rate of every sixteen seconds. Under these conditions a maximum speed of twelve miles per hour and an average speed of eight miles per hour can be maintained where the usual number of stops are made. This figure is probably correct for practical operation.

In the report to the Merchants' Association, of New York, by its Committee on Transportation and Engineering, 1903, it is stated: "With a time interval of sixteen seconds the number of cars that may be moved past a given point per hour is 225." The committee did not believe that on congested streets like Broadway, New York, a service of more than 220 cars per hour passing a point in any one direction could be reasonably expected under the most favorable circumstances likely to occur, but believed that this number per hour was a reasonable estimate of what should be done.

They further stated: "We are confirmed in this belief by our own observations of what is being done at this time in Boston, and the large number of headway observations on Broadway at Chambers and at Houston Streets appear to practically confirm the above conditions."

Experience in Boston partially confirms the opinion of the Commission, for previous to the opening of the Washington Street tunnel it was believed that a point of saturation had been reached, at which time there were operated between two points on Washington Street a maximum of 213 cars per hour in each direction. Previous to the opening of the Boylston Street subway in Boston as high a number as 260 cars per hour were operated in one direction over a very short section of a certain line on a special occasion, but this was made possible by part of the service operating in the Tremont Street subway and around the Park Street station loop.

The Public Service Commission for the First District of New York, April 17th, 1908, ordered "a minimum number of 25 cars in one direction in each fifteen-minute period on certain sections of Broadway." This would be at the rate of one car every thirty-six seconds, and it is believed by some that this is the lowest headway consistent with reasonably rapid movement of cars when all conditions are considered, such as vehicular interference, line intersections, joint usage of certain stretches of track, etc. Further, this thirty-six second headway is exceeded on some lines in New York on certain short stretches of track, where they operate from two to three times as many cars as are required for a thirty-six second headway.

There should be kept clearly in mind also in the study of maximum capacity of surface lines the difference between maximum number of cars that it is possible to operate and the speed consistent with good service.

In view of the above it is fair to assume, therefore, that when street car service for short stretches of track has reached a number slightly in excess of 200 cars per hour capacity the capacity on this stretch of track might be said to have reached a saturation point after which additional arteries must be utilized or other transportation facilities provided. Of course, this figure is also governed by the width and alignment of streets, as well as the size of the units and general traffic conditions.

Very often the saturation point of surface tracks is not the governing feature in added facilities, for necessity for such additional arteries is due to the demands of the public or public authorities for a more expeditious and convenient means of travel. Regardless, therefore, of the cause of providing high speed transportation facilities in the congested districts, there is no question but what the construction of same is unavoidable for one reason or the other.

When tracks on a certain street have reached the saturation point, whatever that may be, and additional transportation facilities must be provided, every conceivable effort should be made to use parallel streets for additional surface tracks, or even build an elevated structure. It is absolute economic waste to recklessly spend enormous sums of money for subway construction merely

*Paper prepared for the mid-year meeting of the American Electric Railway Association at Chicago, February, 1916.