the channel on the north side made it necessary to take up some of these pipe lines, and the oldest pipes were not put down again, as it was found that the erosion of the sand carried by the swift tidal current back and forth across the pipe had worn it thin in spots during its 25 years of service. It was therefore determined to lay an 18-inch main in its place, and this was done.

This erosion of the pipe could be prevented, of course, if the pipe could be buried in a trench across the channel; but the dredging of a trench in 65 ft. depth of water on a bottom strewn with boulders and with the swift tidal current is no easy task. And even if a trench were dug, it would probably be filled by the tidal current before the pipe could be laid in it.

Moreover, the occurrence of any leak in the pipe line is easily detected and repaired by a diver when the pipe line is exposed on the bottom. The city has, in fact, an expert diver at its command whenever his services are required. The number of lines of pipe laid at the two separate crossings is such that the temporary withdrawal of service of one or more lines for inspection or repairs still leaves the city well supplied.

In recent years all additions to the submerged lines have been made with 18-inch pipe instead of the 12-inch originally laid. In laying this heavier pipe, it has been found better to pull it into place in three separate sections instead of in one line, as was done with the 12-inch. After the three sections are in place they are joined by a diver working in about 40-ft. depth of water.

At the first Narrows there have been eleven 12-inch pipes laid; of these, three are still in service. There are two 18-inch pipes, the last of which was laid last fall. At the second Narrows six 18-inch pipes have been laid and are in service.

The flexible pipe used is of the well-known Ward pattern, but has been modified in shape somewhat to reduce the resistance in hauling. A section is shown herewith. This pipe can be deflected 12½° before binding occurs. The pipe is cast in Glasgow and costs $61.50 per long ton delivered at Vancouver. Its weight is about 400 lb. per ft. The total cost of the 18-inch submerged crossings, including the cost of laying, is about $11.50 per lin. ft.

It has occasionally happened that in laying, caulking and testing the pipe a bell has been split at one of the joints. Breaks have also occurred from contact with keels of ships which have gone ashore in the Narrows during foggy weather. Repairs of such breaks have been effected by placing on the pipe to cover the split a sleeve with a stuffing-box and rubber packing at each end.

We are indebted to Edward M. LeFlufy, assistant engineer of the Waterworks Department of Vancouver, for information from which this article has been prepared.

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Keuffel & Esser Company, of New York City and Montreal, have purchased the entire stock, good-will, trade marks, etc., of E. G. Soltmann, New York, who recently went into bankruptcy. The stock was inventoried at more than $100,000. It included the Soltmann specialties, which Keuffel & Esser Company will continue to market for engineers and architects.

In the article, "The Use of Pure Iron by Railroads," which appeared in *The Canadian Engineer*, issue of December 30th, 1915, it was stated, "It is possible to make a technically pure iron containing not more than 10 per cent. of carbon, manganese, sulphur, phosphorus and silicon." This sentence should have read: "0.10 per cent. of carbon, manganese," etc.

## GROWTH OF STREET RAILWAY TRAFFIC IN RELATION TO POPULATION.*

It is evident that the total street railway traffic in any city is a function of the population, as is also the fact that there is a limit to the riding that any one person may conveniently do; or in other words, after a city has reached a certain period in its growth, the number of rides per capita will tend to become constant.

Estimates of future traffic have formerly been based largely, and in our opinion, falsely, upon the "Law of Squares," which is, that "revenue rides increase as the square of the factor of increase of population."

While this has held, and even up to a critical point in population been exceeded in many cities, consideration shows the fallacy of such assumption as applied throughout the total length of the population scale.

The law manifestly cannot be admitted except as an approximation applied to a city in its earlier periods of growth. The problem is to determine empirical formulæ, which, while covering past conditions, give results which may be reasonably applied to the future.

The increase of riding habit in a growing city, assuming that the facilities for transportation keep pace with requirements, may be divided into two independent factors:—

(a) The normal increase due to an increasing proportion of the city's total population, who, because of distance, ride each day, to and from the central business district, together with the increase due to those who ride for social, shopping or other purposes.

(b) The increase in the actual habit of riding, cultivated by improved transportation.

When population is contained within a circle of, say, one mile radius, a street railway is unnecessary, but as the city grows, and people settle outside this zone, a street railway system becomes essential. The effect of this continued growth is to increase the proportion of those living without the central area, and thus of those who daily ride to such district. While it is a fact that the inner zone usually becomes more densely populated, the actual population added to this area is comparatively small, and for the purposes of this investigation it may be assumed without sensible error, that the whole increase is in the outer zone.

It can be demonstrated, however, that the growth of the total traffic with the increase of population in outlying sections, together with proper transportation facilities, follows a well defined law, which indicates that about 520 is the limit of rides per capita per annum.

Combining the revenue passenger and rides per capita information for Toronto, with that of population growth, the following table for the probable future passenger traffic conditions has been compiled, always assuming adequate development of transportation facilities:—

| Year. | Population. | Revenue passengers per annum. | Revenue rides per capita, per annum. |
|---|---|---|---|
| 1914 ..... | 470,000 | 153,000,000 | 325 |
| 1920 ..... | 590,000 | 225,000,000 | 375 |
| 1925 ..... | 705,000 | 282,000,000 | 400 |
| 1930 ..... | 835,000 | 350,000,000 | 420 |
| 1935 ..... | 975,000 | 425,000,000 | 435 |
| 1940 ..... | 1,135,000 | 510,000,000 | 450 |

* From Toronto Civic Transportation Report.