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puller of the country's freight and passenger.

Two decades have passed since the use of electricity began to be a factor in the lighter traffic field; it has been only a matter of half a dozen years since the electric engine on railroad lines began to attract the attention of railroad men. The first important use of electric locomotives on a large scale was the utilization of them in the Baltimore tunnel on the Baltimore and Ohio Railroad. In this instance they were used as pushers, their province simply being to push solid trains with their inactive steam locomotives through the tunnel. This initial use of the electric locomotive was a success.

Results of this success followed soon. In 1898 the New York Central began to give thought to the electrification of its approaches to its New York Grand Central depot, but it was not until 1903 that the increased objection to the atmospheric conditions in the Park Avenue tunnel and the heavy congestion of traffic at the terminal precipitated legislative action directing the complete abandonment of the steam locomotive on the lines entering the Grand Central south of the Harlem River.

**Motors on the Central Road.**  
In the same year the New York Central and the city of New York agreed upon radical alterations of the terminal which were possible only under the use of the electric locomotive, and the railroad determined upon the electrification not only of the immediate approaches to the railroad depot but of the whole suburban zone. That was the first big impetus given to the use of the electric locomotive as a rival of the steam locomotive. Since that step was initiated the spread

of the new idea has been rapid. The Long Island Railroad has installed the electric locomotive on one of its two approaching divisions into New York city. The New York, New Haven and Hartford Railroad has completed the electrification of its lines out of New York as far as Stamford, Conn., and the idea of the company is to complete the electrification to Boston in the near future.

The Southern Pacific is contemplating electrifying fifty miles or more of mountain grade east of Sacramento, Cal., so as to increase the capacity of its tracks over the Sierras. There the greater tractive power of the electric over the steam locomotive will be relied upon to get freight over the summit of the mountains.

Perhaps the greatest thing that has yet been done with the new locomotive is in the St. Clair tunnel, connecting Port Huron, Mich., with the town of Carma, in Ontario, and carrying the tracks of the Grand Trunk Railroad on the line between Buffalo and Chicago. In this instance more than any other where the new locomotive has been tried its peculiar advantages over the smoke giving locomotive have been demonstrated.

**Where Steam Lost Out.**  
It was in 1890 that traffic through this tunnel was started. The tunnel is 3,851 yards in length, including approaches, with a 2 per cent. grade leading up from the bottom level under the river for 1,500 feet on either side. When the traffic was first opened five specially built locomotives with big boiler areas and great tractive powers were installed to take the passenger and freight trains through the tunnel. It was discovered before long that great difficulty and some danger attended the

use of this long tunnel, for if for any reason a train should become stalled for any length of time in the tube the gas and smoke generated by the locomotives became so oppressive as actually to be a menace to the lives of the engineers and train crews. In three instances train crews died at their posts in the tunnel, overcome by the noxious gases from the locomotive.

Making the electric locomotive practicable in turn made necessary the electrification of the St. Clair tunnel. Three large electric locomotives were installed, each being in two independent halves capable of working separately or in couples. The complete unit of two halves weighs 274,000 pounds, is equipped with six motors, each of 240 horse-power. These locomotives are capable of hauling between 1,000 and 1,500 tons up the 2 per cent. grade of the tunnel—a load between 30 and 40 per cent. larger than that which could be hauled by the locomotives formerly in use.

Starting originally as a means of transportation through the principal streets of cities, the electric motor system first extended to suburban resident sections, then to neighboring towns and finally to the point at which it stands to-day, its establishment on high speed passenger lines between the largest cities in the most populous districts of the East. Each advance has been accompanied by increase in weight, size and speed of equipment to correspond, just as the early steam locomotive grew by leaps and bounds into a thing of high efficiency.

While the introduction of electric traction has always been attended after the initial cost of installation by a marked decrease in the cost of transportation the steady growth in favor of the electric locomotive has been due to other advantages which the machine and the system it represents possess.

**Advantages of Electricity.**  
These are material improvement in schedule speed, due to the possibility of greater concentration of power, large increase in traffic capacity, greater reliability of service—in general—and the additional comfort and safety secured to the public by the increased cleanliness and improvement in the control of the car.

The exponents of the electric locomotive point as their chief argument to the comparison between the potential capacities of the steam and the electric locomotive. The rating of a steam locomotive, they say, is based upon the maximum tractive effort which it is capable of giving, while its capacity depends upon the maximum speed at which this tractive effort may be developed. The maximum rate of doing work therefore for which it is possible to design a steam locomotive is established by practical limitations as to steaming capacity of the boiler and width of the firebox.

The electric locomotive, on the other hand, does not generate its own power, but acts merely as a transmitting medium, through which electric power delivered to the locomotive is converted into mechanical power at the driving axles. Each driving axle of an electric locomotive being equipped with a motor, the size and horse-power of which is limited by the speed at which it operates, by the gauge of the track and by the diameter of the wheels, it becomes necessary only to provide a sufficient number of driving wheels to permit the electric locomotive to deliver the greatest tractive effort that the draw bars of a train will stand, at any speed permitted by considerations of safety and reasonable cost of track maintenance.

**Forces Compared.**  
Herein lies the chief advantage of the electric locomotive, its exponents insist, for the increase in speed that may be given to heavy freight trains makes it possible to double and in many cases to treble the tonnage capacity and consequently the earning power of a mile of track. This contention is capable of specific proof. The proof lies in direct comparison.

The powerful twelve wheel Mallet articulated compound steam locomotive built for the Baltimore and Ohio by the American Locomotive Company will develop its maximum tractive effort of 71,500 pounds, working compound, at a speed of less than ten miles an hour, whereas an eight axle electric locomotive having the same weight on drivers and composed of two four axle sections coupled together could be made to develop an equal tractive effort at a speed of thirty miles an hour. Such an electric locomotive could handle three times the daily tonnage of the Mallet compound.

In a paper read before the American Society of Civil Engineers March 18, 1908, William J. Wilgus made an exhaustive comparison between the merits of the electric and the steam locomotive, taking into account the tractive capability of each and the result of this capability upon the tonnage record of roads, the cost of repairs upon both types, &c. He summed up his comparison by pointing to the superiority of the electric over the steam locomotive in the following specific details:

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