THE ELECTRIFICATION OF THE BALTIMORE AND OHIO TUNNELS IN BALTIMORE

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HISTORY

In the early days of the Baltimore and Ohio Railroad there was no direct rail connection between the main line west of Baltimore and that east. This meant that it was necessary to transfer all their trains between these two points by means of ferry across an arm of the Patapsco River. When railroads were first built there was but little traffic and freight was light, so this method proved to be adequate at first. There was not a great deal of time lost in this means of transfer since freight did not travel very fast by rail and it was also thought less expensive than building a road through or around the city. Therefore, all the traffic over the railroad was taken around the city in this way until toward the end of the nineteenth century, when the railroad company began to realize that this method was becoming entirely out of date. The great increase in the amount of traffic during this period, and the rate at which it was now traveling showed them that they must secure a faster and better means of transporting their trains through the city of Baltimore. So this led to the building, in the early ninties, of what is known as the Belt Line, which is a direct rail connection through the city between the main line east and that west of the city.

One of the requirements of the ordinance governing the construction of this line through the city was that the trains be operated by electricity. Not only this, but also the fact that a great deal of this distance was through tunnels, some of which were very long, necessiated a special means for reducing the amount of smoke and gases, and electricity was also undoubtedly the best solution to this problem.

CHARACTERISTICS OF ROAD

That portion of the Baltimore and Ohio Railroad

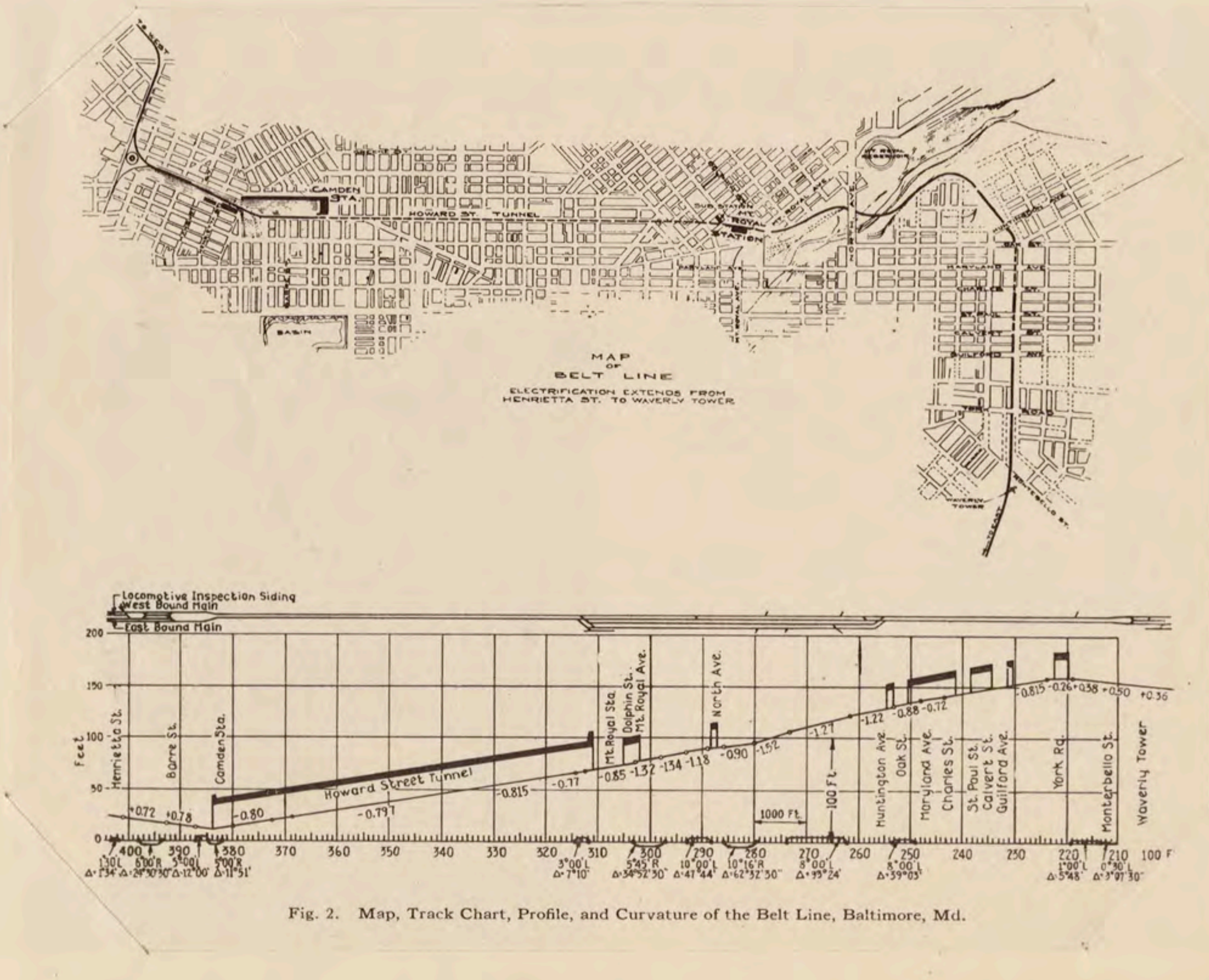

Fig. 2. Map, Track Chart, Profile, and Curvature of the Belt Line, Baltimore, Md.

which is electrified is the part of the so-called Belt Line extending from Camden Station on the west to Waverly interlocking tower on the east, which is a distance of 3.75 miles and lies entirely within the city limits of Baltimore. In this zone there are eight tunnels in all, which amounts to forty eight per cent of the total distance. The longest of these tunnesl is the one between Camden Station and Mount Royal Station which is 7,300 feet in length. This tunnel contains two tracks while there are four tracks between Mount Royal and Huntington Avenue and then two tracks from this point to Waverly.

The portion of the Belt Line over which trains are handled by electricity is entirely upgrade. The difference in elevation between Camden Station and Waverly is 150 feet which gives an average through grade of nine-tenths per-cent. This is a very important fact since trains are handled by means of the electric locomotives in only the upgrade direction. They return light, since traffic operates in the other direction, on account of the grade, without power from the steam locomotive except for starting.

POWER SUPPLY AND DISTRIBUTION SYSTEM

The direct current system is used on this line. The power for the operation of the section was first supplied directly from a power plant built for that purpose and located at the western end of the zone. This station consisted of five 500 K.W. 700 volt direct current generators which were direct connected to tandem compound non-condensing Corliss engines. These were the largest direct connected generators ever installed up to this time. A storage battery substation was also installed near the Mount Royal passenger station, one and three-quarter miles from the power house. This was done in order to obtain more economical operating conditions as well as to improve the voltage on the line. 675 volts were to be maintained at the substation busbars at Mount Royal. Now in order that this voltage could be maintained and also have a lower voltage at the power house the booster system of control was used which included a booster located in the power house. This permitted a reduction of the generating voltage to 550 volts so that current could be used for industrial purposes. The booster limited the power house output to 900 kilowatts for traction purposes. This, with the battery was sufficient to handle one freight train of 1600 tons weight, including electric locomotive, and one light passenger train.

With this method of power, which was the original, the electric energy was supplied to the locomotives through an overhead system of power distribution. The trolley or contact conductor consisted of two "Z" bars so arranged as to form a box like structure with a slot in the bottom. The collector shoe, attached to the locomotive by a pantograph, was allowed to slide in this overhead slot. The trolley was supported outside of the tunnels from towers by catenary construction and in the tunnels by direct hangers.

LOCOMOTIVES FIRST USED

Three electric locomotives were purchased for the operation of this system. These weighed about 96 tons each, and were designated as class LE-1. These three original Baltimore and Ohio electric locomotives were equipped with gearless motors; that is the armatures were mounted directly on the main driving axle, power being communicated to the driving wheel through a spider and rubber driving cushions. It is very interesting to note that not until nearly a quarter of a century later direct current gearless motors operating at 3000 volts were decided upon for the passenger locomotives now used on the Coast Division of the Chicago, Milwaukee and St. Paul Railroad.

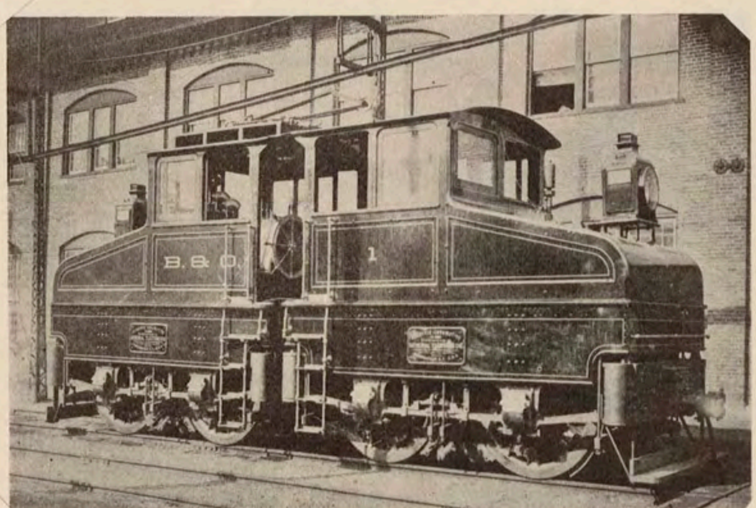

Fig. 3. First Heavy Electric Locomotive Ever Built. Equipped with four 270-h.p. gearless motors

The first trial trip was made with electric locomotive number 1 on June 27, 1894, but the line was not opened for traffic until May 1, 1895. The three original locomotives were used for about fifteen years and then retired. One of them has been preserved in good condition for exhibition purposes as being the first electric locomotive used in this country under steam railroad conditions.

This system of overhead distribution and the type LE-1 locomotives were used for about the first seven or eight years of operation. During this period the railroad company saw that the overhead trolley was causing a very great expense. In the first place it was unsatisfactory as would be expected from our present knowledge of methods of collecting current. It was also constantly in need of repairs since it corroded very quickly due to electrolysis and the action of locomotive gases in the tunnels. Therefore, to cut down this high maintenance cost the overhead conductors were replaced by a third rail system over the entire section.

THIRD RAIL DISTRIBUTION

This system was installed in 1902 and the larger part of it is still in service. As a safety precaution a special form of protection had to be provided at the passenger stations on account of the flush platform construction. Trouble was also met with the third rail at double slip switches. In order to provide a continuous supply of current to the locomotives at these places where the gaps were too great to be spanned by the third rail shoes, a special arrangement of movable third rail had to be used to avoid the necessity of overhead conductors. These were located inside the crossing tracks and at such other points where the standard third rail would be fouled by trains using the crossing tracks. They consisted of a structural "T" iron, which when in the operating position were on a level with the top of the third rail, but were otherwise lowered to the track rail level. When in the lowered position the current was automatically cut off as a means of safety. The rails were controlled from the signal towers, being properly interlocked with the switch levers. This third rail system is still in use and it too has proved to be rather expensive.

After about the first ten years of service the third rail in the Howard Street Tunnel became corroded so badly that it had to be completely renewed. At this time a few changes were made in regard to insulation and support of the rail to overcome certain faults in the original design. This, as modified, has been adopted as a standard design for future replacements.

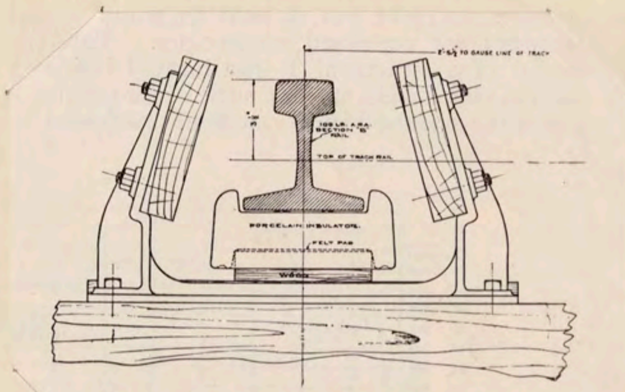

Fig. 3. Latest Type of Third-Rail Construction Adopted. This is now Standard.

SECOND TYPE OF LOCOMOTIVES USED

Soon after the installation of the third rail distribution a second lot of locomotives, designated as class LE-2, were purchased. These locomotives weighed about 80 tons and were designed exclusively for freight service. Three of them were built in 1903 and another one in 1908.

Fig. 5. Three 80-ton Freight Locomotives, Type LE-1 and LE-2, each equipped with four GE-65 Motors hauling freight train

PRESENT POWER SUPPLY

Now that a suitable means had been found for the distribution of current in the third rail system, and with the new type of locomotives that had been purchased, everything seemed to be going very smoothly when the railroad company found they had another problem to face. This was the one of power supply. With the great increase in train weights and in the amount of traffic handled a condition finally resulted where the old system of generation was totally inadequate to meet the demands. After a careful study of the situation it was decided that if power could be obtained from a large central station plant it would be more satisfactory from an operating as well as economic point of view. Therefore in 1909 a contract was drawn up with the Consolidated Gas, Electric Light, and Power Company for furnishing power in the form of 13,000 volt three phase, 25 cycle current. A synchronous converter substation was built by the railroad adjoining the Mount Royal battery station large enough for installing three 1000 K.W. 650 volt synchronous converters with their necessary auxiliaries, and still having sufficient space for an additional machine. Three such machines were installed at this time and the battery used on the old system, which was of a capacity of 3200 ampere-hours was retained for peak work. The capacity

Fig. 7. Mt. Royal Substation of the Baltimore and Ohio Railroad

of this station was sufficient for handling two freight trains of 2400 tons including electric locomotives, and one passenger trains simultaneously. This method of purchased power soon proved to have decided advantages over the old system, not only from an economical but also from an operating standpoint. The high peaks occurring with the starting of trains on the grades could be absorbed by the central station system with no disturbance. The railroad could increase indefinitely the demands for power without a new outlay of capital for power plant equipment, and also the necessity of having to carry reserve plant equipment was eliminated.

With this new method of power the old power plant was abandoned. In 1914 purchased service was extended to cover all the electrical requirements of the railroad as for lighting and other industrial purposes, and the old Mount Royal battery was abandoned as further operation of it was considered unnecessary. At this time another 2000 K.W. rotary converter was installed which gave the system sufficient capacity to handle simultaneously two freight trains of gross trailing weight of 2840 tons each.

PRESENT LOCOMOTIVES AND TRAFFIC

With the new method of power supply a third lot of locomotives were built weighing approximately 100 tons each.

Two of this type were purchased in 1910 and two more in 1912 and were designated as class OE-1 and OE-2. In 1923 these locomotives were ballasted up to 120 tons and at the same time two similar locomotives were built which were designated as class OE-3.

Fig. 6. One 100-ton Freight and Passenger Locomotive, Type OE-1 and OE-2, equipped with four GE-209 Motors hauling passenger train

Fig. 7. Two 100-ton Freight and Passenger Locomotives, Type OE-1 and OE-2, each equipped with four GE-209 Motors hauling freight train

These six locomotives are now in service and are used on both freight and passenger trains. The service in the zone is very much like helper service except that the road locomotives furnish no assistance. Two of the electric locomotives are used to a train and are coupled together to operate as one. On account of the shortness of the run the steam locomotives are hauled through the zone with their trai trains. The electric locomotives return light, as traffic operates in the westbound, or down grade, direction without power from the steam locomotive.

Two 120-ton Freight Locomotives Delivered in 1923

The present maximum rating for freight trains handled on this line is 2450 tons not including the steam locomotive weighing about 270 tons. Two OE-1 or OE-2 locomotives haul these trains at a speed of 15 miles per hour which is nearly twice the speed made by Mallet steam locomotives on corresponding grades with full loading. Present traffic consists of handling about 33 trains daily.

This electrification was the first work of its kind, the Baltimore and Ohio being the first trunk railroad to adopt electricity as a motive of power.

Note:

Data for the preparation of this thesis was found from articles by J. H. Davis, Chief Engineer, Electric Traction, Baltimore and Ohio Railroad, published in the November, 1914 and October, 1923 issues of the General Electric Review.