ASPECTS OF STEAM RAILWAY ELECTRIFICATION.

Important Advantage of Electric Locomotive Is Ability to Haul Heavy Trains Over Grades at Same Speed as on a Level.

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Let us see what has thus far been accomplished in trunk line electrification and what is likely to be done in the future.

We have today at least seven prominent steam railways that are using electricity as motive power on one or more of their main line divisions.*

(1) The Baltimore & Ohio, at its Baltimore terminal.

(2) The New York Central, at its New York City terminal.

(3) The New York, New Haven & Hartford, at its New York City terminal and at the Hoosac tunnel.

(4) The Pennsylvania, at its New York City terminal, and on parts of the West Jersey & Seashore.

(5) The Great Northern, at the Cascade tunnel.

(6) The Grand Trunk, at the Sarnia tunnel, under the Detroit river.

(8) The Michigan Central, at the tunnel under the Detroit river.

With the exception of the West Jersey & Seashore, every one of these electrifications was caused through the presence of a tunnel, which made further operation by steam locomotives either difficult or impossible. Whatever economies in operation were secured through the use of electricity may be said to have been incidental in all these cases.

Does this mean that electricity will be restricted to places where tunnels form a hindrance to steam operation? A careful examination of the matter shows nothing to confirm such a view. Smokelessness is only one of the advantages of electric traction. As matters stand today it will hardly be considered its most valuable one. There is one that is likely to prove of much greater importance. It is the fact, that the electric engine possesses inherent qualities, which make it a much more powerful traction machine than its steam rival. To show just how this characteristic has already been utilized and to what extent it is likely to influence further developments is the purpose of this article.

The work which any given engine can do is dependent on three things, tractive power, boiler power and engine power, and it is limited in three ways.

(1) The tractive power is limited by the weight of the engine, or rather by that portion of the weight which is placed on the driving wheels. Any increase in weight on drivers means a proportional increase of tractive power, and for any given weight on drivers there is a certain maximum power which the engine can exert, and beyond which it must necessarily slip its wheels.

(2) The size of the boiler determines the quantity of steam which can be produced in a given time, and thus limits the steam producing or boiler power. If the engine uses more steam than the boiler can produce, the boiler pressure will fall and the engine will then be unable to turn the wheels.

(3) The capacity of the cylinders in a steam engine, or of the motors in an electric engine, limits the mechanical or engine power. If these parts are not sufficiently powerful, then the engine will be stalled, even while utilizing to the utmost a full pressure of steam and while yet unable to slip the drivers.

It may be said at once that the last is in general an unpardonable fault for any engine to have, because it is an absolutely needless sacrifice of a good part of its working capacity. With proper care in the design of its steam cylinders, or proper choice of the electric motors, it is always feasible to make the engine power in excess of either the tractive power or the boiler power, or both. The limit to the work which can be done by a well designed engine need therefore never lie in its motor part. It is always due either to insufficient tractive power or insufficient boiler power.

On these two points the electric engine shows its superiority over the steam engine. The electric engine has the boiler in the power house, and its size can thus be determined without reference to the limitations which are imposed on the boiler of the steam engine by the physical characteristics of the track and of the fireman. In other words, by proper design the limitations of the boiler power can be entirely removed in any system of electric traction.

Similarly, we find that the limitations of tractive power may be practically eliminated wherever electricity is used, because the electric motor lends itself to subdivision of power with such ease, that it is quite possible, in case of necessity, to turn any desired number of axles into driving axles, and thus to utilize any desired part of the weight, up to the full weight of the train, for tractive purposes. The tractive power which is thus made available is away beyond anything that is likely to be demanded in railway work.

Now let us see how these two characteristics of the electric engine may be utilized.

Our contention is, that electricity is peculiarly suitable for the relief of all congested spots on the present steam roads. We have two main cases of congestion, namely, terminals and ruling grades.

We started by saying that the electrification of the New York terminals of the New York Central, the Pennsylvania and the New Haven railways was largely caused by the necessity of avoiding smoke in the tunnels that form a part of these terminals. But it would be wrong to assume that the matter stopped there. The men who had charge of these installations fully realized the other advantages which were thus incidentally placed at their disposal. In such cases it is especially the removal of the limitations on tractive power which is of considerable value.

It is a fact well known to all superintendents of motive power that it is difficult to make a fast schedule in dense suburban passenger traffic, even with the most powerful steam engines, especially designed for such service. The reason is that with steam locomotives there is a distinct limit to the amount of weight that can be placed on the drivers. From this results a limit to the tractive power, and consequently a limit to the ease with which heavy trains can be started and brought up to the speed. Even the highest obtainable rate of acceleration is too low to give a really satisfactory schedule speed when stops average about one mile apart. Furthermore, the number of cars that can be hauled in such a train is distinctly limited.

Electricity changes the situation completely. Any number of axles can be equipped with electric motors, and thus the tractive power can be raised to any desired amount. In actual practice an electric train can readily be accelerated two or three times as fast as even a light steam train, and there is practically no limit to the number of cars that can be placed in an electric train. The congestion is thus relieved in three ways, first by the possibility of using larger trains, second by the chance of higher schedule speeds, and third by the greater ease with which

* [As our readers well know, several railways have adopted electricity as motive power for suburban or interurban service. For example, the Southern Pacific electrification of suburban lines in Oakland and adjoining suburbs was described in the issue of September 13, 1912. The same system is now electrifying a number of lines in the vicinity of Portland, Ore. The West Shore has electrified a portion of its line between Utica and Syracuse, N. Y., operating passenger service in conjunction with steam freight service as described in the *Railway Age* of June 21, 1907.—EDITOR.]

the trains can be moved out of each other's way, that is to say, by the possibility of decreasing the interval between trains. In actual practice all three methods are usually combined with resultant satisfaction to passengers as well as the railway.

In the case of congestion due to severe grades, on otherwise level or low-grade lines, the conditions are reversed. In such instances the maximum tractive power is usually quite sufficient; in other words, the obtainable acceleration is satisfactory, but it is the boiler power which causes trouble. In order to lift the train up the grade, the engine must consume more and more steam until a point is reached when the boiler is unable to produce any longer what the engine requires. Then, either must the train weight be reduced, or its speed, or both. This is what actually happens on the ruling grades of most of the lines crossing the Alleghenies, the Rockies, and other mountain ranges. Helper engines mitigate the nuisance to a certain extent, but there is a limit to the number of helpers that can consistently be used on one train, and when this limit is reached, the trains are made lighter at the bottom of the grade, or their speed is cut down, or both.

Here, again, we find that the use of electricity completely changes the situation. There is no limit to the power which the boilers in the far-off power house can produce, and this power can very readily be carried to the engines in the form of electric current by means of the third rail or overhead contact line. Thus it is possible to concentrate sufficient power in an electric locomotive to take any train up the grade in the same composition in which it arrives at the bottom of the grade, and with the proper type of motor this can be done at the same speed at which it is run on the level. The congestion produced by the grade is thus effectively removed. In fact one might almost say that for electric operation the vertical profile of a road loses all of its terrors, and trains can be taken over the most broken profile almost as well as over the level road.

We see, therefore, that the excess power of the electric engine can be made useful in at least two ways. The electrification of terminals is likely to make further steady, but comparatively slow progress. As a matter of fact, there are not very many places where terminal congestion has reached such a state as to make the use of electricity necessary, or even very important. The electrification of heavy grades, however, is destined to find more and more favor, especially because the business of the country is on the increase and any congestion now existing is therefore likely to be aggravated in the near future. At the Cascade tunnel of the Great Northern a heavy grade has been electrified in addition to the tunnel, and the results there obtained are certainly quite encouraging.

As regards the electric system to be used, too much importance has been attached to this subject in the past. There are today at least three well established electric systems, namely, the continuous current or direct current system, the single-phase alternating current system, and the three-phase system. Any of these can no doubt be used to electrify almost any service found on American roads. Which is the best for any given case can readily be determined by men who are expert in such matters. Generally speaking the continuous current system will probably be found best suitable in terminal electrification work and the three-phase system in grade work. The single-phase system, for which rather extravagant claims have been made at times, does not seem well suited for work of the heavy kind. It is true that Mr. Murray claims that the New Haven saves 15 per cent. by the use of the single-phase system, but his claim has in no way been substantiated, and those who know believe that the case is the other way round, and that the New Haven would be better off if it used one of the other two systems. But this is indeed not a vital point. Just as there are many different types of steam engines, and at least three types of approved valve gears, so is there room for many different kinds of electrical motors.

The fact which is important is that in the electric locomotive of proper design we have an engine of much greater working capacity than can ever be obtained in a steam engine. This greater capacity can be used, either to give greater acceleration in terminal work, or to move heavier trains at higher speeds over ruling grades. The latter employment in particular is likely to prove of great value in the case of roads where a severe grade produces a congestion, and thus a decrease in the traffic capacity of the whole line.

In a future article we will investigate whether grade reduction, or the use of Mallet engines, or both together, can afford as great a return on the capital invested, or offer the same operating advantages as electrification.

PROPOSED FEDERAL FULL-CREW LAW.

On April 8, 1912, circular No. 31 on the above subject, was addressed to the railways by the Special Committee on Relations of Railway Operation to Legislation asking for the cost of compliance with the bill pending in the house of representatives, requiring all freight trains of twenty-five cars or more to have a crew consisting of an engineer, fireman, conductor and three brakemen. Replies to this circular were received from 143 operating companies, operating 195,049 miles of road.

A summary of the replies has been tabulated by the committee as follows:

Trains affected by existing state laws, per annum..	678,661	
Additional trains affected by proposed federal law in states now having full-crew law, per annum....	468,483	
Trains affected by proposed law in states now having no full-crew law, per annum..............	3,211,056	
Total trains affected by proposed federal statute, per annum		4,358,200
Cost of compliance with existing state laws, per annum	$1,797,590	
Additional cost of compliance with proposed law in states now having full-crew law, per annum....	1,342,237	
Cost of compliance with proposed law in states now having no full-crew law, per annum...........	10,255,791	
Total cost per annum of compliance with proposed statute		$13,395,618

It will be noted that in the states in which there already is a full-crew law affecting freight train crews, the additional cost entailed by the proposed federal bill will be $1,342,237 per annum, or approximately 75 per cent. of the cost of compliance with the state laws already in effect.

In states where no such law now exists, the estimated cost of compliance with the proposed federal act will be $10,255,790 yearly.

It will be noted further, that the total cost of compliance with the proposed federal bill will be $13,395,617 a year, an increase of $11,598,028 over the annual cost of existing state laws.

In return for this expenditure, which is 5 per cent. on $267,912,355, the committee states, no additional safety will be provided for the public or employees; but, on the contrary, in many instances the operation of the trains will be rendered less safe by reason of the multiplication of useless employees.

The bill (H. R. 21219) was introduced on March 2, last, by Representative Sabath of Illinois, and was referred to the committee on interstate and foreign commerce. Its author seems to have intended to require three brakemen on all freight trains, however short, the essential clauses being worded as follows:

"To compel railway companies . . . to equip *all* of its freight trains. . . . No railway shall equip any of its freight trains with a crew consisting of less than an engineer, a fireman, a conductor, and three brakemen. . . . This Act shall not apply on lines where said freight trains are so operated shall consist of less than twenty-five cars, it being the purpose of this Act to require all railways engaged in interstate commerce, *whose line or lines are engaged in hauling freight trains consisting of twenty-five cars and more,* to equip the same. . . ."

The bill provides for a penalty for each offense not less than $100, nor more than $500, and that each freight train so illegally operated shall constitute a separate offense.