THE RAILWAY OF THE FUTURE.

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THAT the railway system of the present is destined to a more rapid rate of development than in the past is one of the signs of the times. Splendid as is its record, it is guilty of killing and wounding somewhere near 33,000 people per annum in the United States alone. It carries its passengers at an average speed of only about twenty-five miles an hour, and it burns extra coal enough to carry with each one an average dead-weight of from one to two tons, running up to six tons in some classes of trains.*

For the attainment of the highest perfection in the three things which railway passengers most desire, safety, speed and cheapness, we must institute certain radical and sweeping reforms. In carrying these out, the most important features to keep in view for securing safety would be some system of practically non-destructible track, on which the wheels could be confined mechanically, and the cars or trains kept blocked a proper distance from each other. For speed and economy we must have a lightening of the cars, upon principles and to a degree which have never yet been attempted in the construction of any vehicles except bicycles and tricycles.

For such track construction, that is for absolutely non-derailable cars, a metallic tunnel obviously forms an ideal road-bed, inasmuch as a car can be confined therein as surely as can a piston in its cylinder. The same general principle (of holding a car down otherwise than by the present system, of ballasting with unnecessary weight) can obviously be applied to an elevated road, but not successfully to any sort of a surface road with grade-crossings or other interferences. Our future railways will embody both the over- and under-ground methods, as circumstances shall dictate. In favor of tunnels it must be remembered that they lose much of their unpleasantness when brilliantly lighted by electricity, and when no fire, smoke, steam, water or gas is permitted within them.

In designing the non-derailing roads of the future, it is evident that one of the enormous difficulties to be overcome will be how to manage switching from one track to another, or, preferably, how to abolish switches altogether. These are not, however, unsolvable

* For an analysis of train weights, see an article by the writer in *The Forum*, Jan., 1891.

problems. An incidental advantage of an unbroken track is its adaptability to some system of grip track-brakes, whereby fast-running cars can be stopped in distances much shorter than where mere wheel-stopping is depended upon.

To the student of this subject a dozen years ago, it seemed possible, by sufficient care and expenditure, to make a railway almost absolutely safe and comfortable, but in the attainment of very high speed there arose insurmountable difficulties, chiefly on account of certain limitations in the locomotive. There were, it is true, rumors in the air of electric railways abroad, but few American engineers would have risked their reputation for sanity by seriously expressing an opinion that a new era of propulsion was dawning. So rapid, however, have been the strides of electrical science that the mist of doubt is cleared away, and looming up in the clear atmosphere is a newly-created warlike steed, with fire in his nostrils, who has already slain his thousands of street-car mules, and is panting for a fray with the great iron horse himself.

Recent statistics tell us that there are now running, in the United States alone, nearly 4000 electric street-cars, upon 2000 miles of track, with as much more similar plant in course of construction. These cars run faster, more cheaply and under far more perfect control than do their predecessors, the horse-cars. In America this system of propulsion is commercially but four or five years old, and is barely out of its experimental stage; yet it is a magnificent practical success—with more than $50,000,000 invested in it—and this under some of the worst conditions possible for railway work. Some of these conditions consist of very narrow wheel-flanges; rough tracks, obstructed with water, snow, mud, gravel and foreign vehicles; curves as sharp as thirty feet radius, grades as steep as 12 per cent. etc. A service more nearly resembling that of our present steam-roads is that performed by the City and South London Railway, which is practically the first underground electric road in the world and is already a great success, having during the eighteen months of its existence carried more than 7,000,000 people, with a run of over 500,000 train-miles. Although not entirely perfected, a road like this forms one of the notable object-lessons by which we are learning how to travel.

In the light of such experience there is no question whatever about the success of either a subterranean or an elevated electric road, if properly designed to meet the new conditions involved—and the running may be at *any speed* which can be made safe. We may, therefore, in our further study of the ideal railway, positively leave out of the question the steam-locomotive. Great as have been the performances of this wonderful and beautiful monster, he not only refuses to climb very steep grades but he has utterly failed, in the matter of speed, to keep pace with his improved behavior in other respects. In proof of this we have records of English engines going at the rate of 75 miles an hour, forty years ago; and that is the maximum work of our present machines, although they may have occasionally touched a 90-mile rate as a phenomenon.

Until quite recently regular railroad-men have been inclined to smile at the mention of electric propulsion, but a great many of them now admit that it is probably the proper thing for elevated lines and other special constructions. Comparatively few, however, are yet ready to accept the probability of electricity displacing steam upon the ordinary railways already in existence. These, who are among the most progressive in our great corps of railway managers, are carefully watching developments, and stand in a waiting attitude ready for whatever revolution may come. The electrical engineers, as a rule, are quite sanguine about the future use of the electric current on all classes of railways, and they are naturally proud of the great achievements that have already been made in street-car service. The attitude of mechanical engineers in general is one of doubt, especially as regards the ordinary railway. Several carefully-studied papers have been written lately with long arrays of figures which, in their authors' estimation at least, respectively prove both sides of the argument. The writer confesses that he has hardly made up his mind upon this difficult question, but he inclines to the opinion that the experiment will be tried in the near future, and that it will result in a fair measure of success, especially if the cars are made lighter. We cannot, however, expect extremely high speeds with our present form of roadway, on account of the liability to derailment and collision with foreign vehicles.

A question which has been agitated a good deal among engineers who admit the desirability of electric propulsion in general, is whether a train shall be drawn by a so-called electric locomotive, or whether each individual car shall be made self-propelling, by having the electro-motors upon one or more of its axles. There are many who favor the former method, but it is difficult to see why—unless because it is a less radical departure from the old system. The arguments in the case of steam-propulsion are all on one side of this question, and absolutely show the necessity for a separate locomotive, it being entirely impracticable to divide up the boiler and engine, with their complicated mechanism and the necessity for skilled attendance, among a number of separate cars. Fortunately the heavy load which it is necessary to carry, in the shape of fuel, water, boiler, etc., gives nearly enough weight for traction purposes—that is for the friction necessary to keep the wheels from slipping on the track; although there are frequent exceptions in the case of wet rails and up-grades. If we could do as the old woman in the story advised the Mississippi steamboat captain to do, "bile our water on shore," and if, furthermore, the steam thus generated could be picked up in small quantities as it was wanted, along the track, and could be used in a small simple rotary engine attached to each car-axle, then the best course might be to abolish the locomotive and run the cars as self-propellers.

In using electricity we have just the conditions that we cannot have with steam: a rotary motor which is as simple, as far as its motions are concerned, as a churn or a grindstone; which can be mounted upon or geared to the car-axles direct; which requires but little or no attention while running and which picks up the current of electricity that drives it by a simple wire connection, as it progresses along the line. Furthermore, this electricity can be generated in stations located at proper intervals along the route, where the water is boiled "on shore" to run the great engines which produce by means of dynamos the required current. This water, moreover, is boiled with a far greater degree of economy than it possibly can be in the locomotive, with every advantage in saving of fuel and attendance which can be gained by large triple- or quadruple-expansion condensing-engines. The great economy thus obtained in coal consumption will undoubtedly go far to offset, if it does not entirely overbalance, the loss of electricity by waste along the line, and by a certain inefficiency in the dynamos and motors.

One of the most obvious advantages of this system being the absence of any real necessity for a locomotive, it would certainly seem very foolish to nearly or quite double the total dead-weight propelled by building such a machine, and ballasting it with enough iron or brickbats to get the necessary traction, when each car can itself carry the required simple motor mechanism; and when, with its own weight and that of its passengers, no matter how lightly it may be built, it will be sufficiently heavy for tractile purposes.

A peculiar and valuable feature of electrical propulsion is the ability to frequently dispatch short trains, or single cars, with as great economy of power as long trains—each car being able to select, at each instant of time, the exact amount of electrical energy needed for moving itself and its load, and this at any inclination of grade that it happens to be upon. Besides, the adaptability of the current to its functions permits a car under some circumstances to be braked electrically, in which case it is possible to repay power to the general fund, instead of wasting it in brake friction.

It is of course unlikely, for very many years to come, that there will be any radical change in the road-beds of the vast net-work of our existing railways, except in the matter of stronger tracks and bridges, and the avoidance of grade-crossings and some other evils which are now being reformed upon our richer lines. Such reforms will bring them only to the high grade of efficiency and safety already existent upon the English and some other foreign roads. It is probable, however, that some form of highly-organized elevated railway, built with scarcely any regard to the saving of first cost, and with a vast amount of dead-weight in the track, rather than in the rolling-stock, will before many years be built upon some route where the traffic is large enough to pay the interest charges on an enormous first cost, in addition to meeting the comparatively light running expenses. This road will be so built as to make derailment impossible; will be without switches or crossings; will have running upon it, driven by electricity, light narrow cars, either singly or in short trains, which will be sharp in front and smooth upon the sides, after the manner of a bird, in order that air-resistance may be reduced to a minimum. If, as is probable, the electricians succeed in perfecting an electric block-system (something that has been already experimented with in England by the lamented Professor Jenkin and others) which shall make it physically impossible for one train to approach another, either before or behind it, within a pre-determined distance, then there need be no speed limit except that due to the requirements of not braking a car so rapidly, within a given available stopping distance, as to throw passengers violently from their seats.

The actual speed which will be obtained is of course extremely problematical as yet, but there seems to be no inherent mechanical reasons why we should not, on long and absolutely clear stretches of track, obtain a velocity approaching two hundred miles an hour. There will of course be no drawbridges or other artificial gaps, and everything about the roadway and its foundations will be built with such an enormous surplus of strength, toughness and rigidity that no ordinary causes can possibly disturb it. The cars of this ideal track will be so confined that they cannot leave it, even should their wheels and other machinery be entirely broken up. Such machinery will of course be made of the toughest material, but will be so placed as to do little damage should it meet with accident due to hidden structural weaknesses.

These cars will be so lightly built that the coefficient of deadweight will be very small, and the stopping and starting quickly will be, even at the high speeds attained, a comparatively easy matter. The old-fashioned notion that the power required to move a vehicle is as the square of the speed has in recent years fallen into disrepute, and although we have not yet made sufficiently definite experiments to accurately formulate a law concerning this matter, it seems tolerably certain that while the air-resistance may approximate this rate of increase, it will not entirely follow it, if the front of the train is shaped to properly cleave the atmosphere. The other resistances, due to friction, etc., probably increase very nearly as the speed, and will, therefore, cause but little more loss of power at a high than at a low speed, when a given distance is considered. What refinements our inventors may attain to in the way of roller bearings, as they have already done in the bicycle, and what they may do in the way of guiding the car sidewise by rolling friction, rather than by the grinding friction of wheel flanges, we cannot yet determine.

The cars in question will of course be lighted, and probably heated, by the same electric current which drives them. If it should prove practicable to use rubber tires upon the wheels it is easy to imagine the delightful smoothness and quietness with which they will run—and this through air untainted with sand, cinders or steam-whistles. If, to secure lightness, they are not fitted with as many hotel conveniences as are our present "Pullmans," it must be remembered that the trips will be so shortened that the want of them will scarcely be felt, at any rate upon routes of moderate length.

To make the high speeds referred to practicable, curves will be avoided as much as possible, and when they do exist they will be made of the greatest practicable radius. This method of line location will, however, be favored by the elevated form of construction, and by the fact that it will not be necessary to pay so much attention to avoiding grades as is the case with our present roads. Not only, as before stated, can an electric car mount a much steeper grade than we now deal with, but from the inherent nature of this method of transmitting power it is possible (though the principle is not yet fully developed) to brake a car electrically upon a down-grade, so that for the time being its motor becomes a dynamo. This generates an extra current and restores it to the line, which in its turn supplies some of the necessary excess of power at the up-grades. Thus a track may undulate up and down to a considerable extent without the disadvantage of great loss of power inherent in our steam railways. This principle will therefore favor the arching upward of bridges in mid-channel, for clearance of boats, without elevating the approaches to so great an extent as is now done.

In regard to the location of the pioneer railway of the type indicated, it seems reasonable to infer that it will be built either between London and Liverpool or between New York and Philadelphia—for the reason that the traffic is probably of greater volume, upon these routes than anywhere else in the world. It is not likely, however, that sufficient capital could be procured at the start for so large an experimental investment as would be required to build, for instance, the whole ninety miles between the last-named two cities. It would seem better that a small portion of such a line should be built first, but long enough to give a proper trial to the high speed desirable, without spending all the time in starting and stopping. It may be that when one of the proposed new bridges is built across the Hudson river the best place to try the first section of this "railway of the future" would be from the heart of New York city to some central point in a busy city like Newark, keeping in mind an open route for the future as an extension to Philadelphia.

Should a few hundred miles of such a road as this be built, and become a success as regards safety, comfort, speed and economy, as undoubtedly it eventually will, after sufficient experimenting, the new system would gradually spread throughout the world, obviously concentrating itself at first about large cities where the traffic was sufficient to warrant the expenditure. The lessons learned by such a system of transportation would enable the ordinary roads to adopt many of the new principles involved, and we should see a gradual evolution of new methods, leading to changes of which we now can scarcely dream. These changes would spread gradually away from the large cities to the more thinly-populated country districts. They would at first affect passenger lines only—the old roads, with their old methods, being kept mainly for freight purposes, and perhaps for local short-distance passenger traffic. The new principles and methods would probably eventually extend in whole or in part to freight traffic also.

It is difficult now to say how the changes indicated will come about, whether by a comparatively slow process of evolution, adding improvements little by little to our present methods, or whether capitalists will be found with sufficient nerve to precipitate the sudden change of methods which our rapidly-gained electrical experience would seem to call for. If it be asked how the actual work is to begin, the answer is: by the earnest coöperation of a body of engineers and scientists, backed by a syndicate of bankers. Such a great work cannot, if it is to prove successful, be left to a few individuals, or to an ordinary company whose sole object is to build as cheap a structure as possible upon which to run their trains. The matter should be taken up by a powerful syndicate of capitalists, who should employ a commission of the ablest engineers available. This commission should not be composed of railway engineers alone. Such men, although perhaps of great ability in practically constructing and managing our present systems, are educated too much in conventional grooves to take the broad view necessary in instituting so radical a change of methods. In their defense it should be said that it is their business to be conventional, and their employers, the railways, could not afford to have them otherwise. There should be, however, enough of them in the new commission to give ballast and conservatism. Then there should be thoroughbred mechanical engineers, with an eye to all possible constructions based on correct principles, no matter how novel the form. There should be a sprinkling of professional inventors to give originality, and last, but not least, a corps of electricians of the highest standing, especially in regard to practical experience in street-railway work. That it is possible for such a body of men to devise something better than our present system, at any rate for special locations, is a matter hardly to be doubted.

If we may judge by the wonderful stories occasionally appearing in the daily newspapers there are already some schemes on foot, for extremely rapid transit. They seem mostly to be based too nearly upon old forms of road-bed, or else to have run wildly to some absurd extreme. They all appear to be in harmony however, in regard to making the cars too heavy and the track too light and cheap. Furthermore, some of them are located at ground level, which would of course be fatal—in more senses than one.

It is hardly necessary to touch upon the great importance to the traveling public of far higher speeds than we have been accustomed to conceive of as practicable. There are now carried by the railways between New York and Philadelphia not far from 5000 people every day, besides all of those who travel only a part of the distance. This is about 1,825,000 through passengers per year. If the time spent in these journeys could be shortened from an average of say 2½ hours to a little less than one hour, the saving to the passengers would be three million hours ; and this with a speed only a little more than 100 miles per hour. If we value the time of these people at an average of twenty cents per hour we have $600,000 saved annually—or the interest at 5 per cent. on $12,000,000. Should it be found practicable to make two or three stops *en route*, these figures would be largely increased by the way travel.

What extra fares the passengers would be willing to pay for this fast service it is difficult to predict. Such a radical change in the speed and convenience of travel would however cultivate and enormously augment the *traveling habit*. Not only would many classes go much oftener than now, because of the time saved *in transitu*, but because of the convenience of being able to start at such frequent intervals, as say, ten, fifteen or twenty minutes. Of the social and commercial changes that will be brought about when a New Yorker finds Philadelphia practically as near as are Brooklyn or Hoboken now, we can at present form no adequate conception.

The number of passengers traveling locally both ways between New York and Newark is not far from 16,000 daily, and is constantly on the increase. Such part of this number as could be tempted to take an eight or ten minutes spin (when there is a bridge built) instead of going by the old routes, would form a nucleus of patronage which would be worth considering. It would therefore seem probable that this location is destined, perhaps long before the twentieth century shall dawn, to be the scene of an experiment which will inaugurate the New Era in railway construction and operation.

In regard to the future development of travel by rail, there can be no doubt that it will be largely stimulated by all improvements which tend to make it safer, more rapid and cheaper. The recent wonderful increase of patronage upon the Hungarian railways, due to the adoption of the "zone system," wherein the fares are not only cheaper, but simplified to an extent that appeals to the imagination and excites a desire to ride, is a lesson that we shall sometime heed. Something of the kind may in this country be destined to do for our passenger traffic what cheap and uniform postage has done for our letter-writing—especially if we can contrive some way of managing our railways as a unit, and thus get rid of the loss and waste due to competition and litigation. It would be interesting to know the effect that would be produced upon our volume of travel if we could combine with some of the mechanical advantages indicated in this essay an absolutely uniform mileage ticket, to be bought anywhere like a postage stamp, at, say, one cent a mile, and good at any place and time until used. When we combine with it the coming 24-hour numeration of time (which has already been adopted by The American Society of Civil Engineers and by several railway companies in this country, as well as by the Governmental railways of India) and some simple system of universal time-tables, the traveler will begin to be relieved of the brain and nerve stresses which now add so much to the fatigue of his journeying.

It must be remembered in favor of the general reform herein predicted, where an enormous investment in permanent-way allows safety and rapidity of motion in rolling-stock, with cheapness in its construction and operation, that volume of travel, and consequent income, can be almost indefinitely extended without very much increase in interest charges. This is especially true with extremely high speeds, on through lines, because a great many trains, or single cars, may be upon a track at once and yet be "blocked" a sufficient distance apart for safety. The principal increase of expenses is obviously for the cars themselves, for attendance thereon, and for the comparatively small amount of power required to drive structures so lightly built and running so easily as the steel-aluminum-rubber-leather-paper passenger coaches of the new *régime*.

If we look about us for the need and manner of the improvements indicated, we find that our methods of travel need reforming; hence the *Why*. The experience of three-score years and the scientific knowledge of to-day, personified in the engineers of Europe and America, will show us the *How*. Shall not the last decade of this century of science show us the *When?* Are our capitalists ready with the *Wherewithal*, spending their money that more may come, and crowning with laurels their own brows as the men who first nurture into vigorous life-buds and blossoms that shall ripen later into the full fruition of the "Railway of the Future"?