CHAPTER I

THE WHEEL AND THE PUBLIC

ONE of the greatest of unknown men of genius was the inventor of the wheel. Probably—as in the case of most inventions—he shares the credit with others who prepared the way for him by discovering that heavy weights could be more easily rolled than dragged. But, whatever the origin of the wheel and axle, the combination was so admirable that it remained unchanged in its essential features for centuries and still forms the primary element in locomotion.

Some of the earliest forms of vehicle can be found co-existing with the very latest. In Oporto, for instance, there are electric tramways, but there are also ox wagons which seem to belong to the childhood of the world. The wheels are rigidly fixed to rotating axles (the oldest known arrangement) and the supports of both the front and the back axles are rigidly fixed to the wagon. The result is that the vehicle cannot 'steer' and must be dragged round corners. Some time ago the authorities, realising at last that this dragging was ruinous to the road

surfaces, made a regulation that all wagons should have their front axles pivoted. This attempt at improvement caused more agitation than the Revolution itself. The owners of wagons argued—with perfect justice—that the rigid wagon had served for innumerable generations; and they refused, in the face of fines, to make the change. Their resistance was so general and so dogged that the law became a dead letter, and the people reverted with great content to the ancient system which divided the business of local transport between yoked oxen and women who had been trained from girlhood to carry heavy loads upon their heads.

This example of conservatism, though extreme, is characteristic of the attitude of the general public towards innovations in locomotion. Until mechanical power came to be used, there was—for many centuries—nothing which could be described as a radical innovation in transport. Roads were multiplied and improved; some advance was made in the design and construction of carriages; and the organisation of posting and stage-coach services was developed. But little more was done. Compared with these superficial changes, the idea of using steam power on the highway or on a railroad was so drastic a change that it roused tremendous opposition. The railway companies fought this opposition and overcame it, but the use of steam carriages on ordinary roads was

postponed until the appearance of the petrol motor encouraged a movement—once more against strong prejudice—for the repeal of the legislation which restricted the use of mechanically-propelled vehicles on the roads. In a similar way horse tramways were violently attacked; and their conversion to electric traction was opposed by a determined minority in every town. More recently, there was a vigorous agitation against the substitution of motor omnibuses for horse omnibuses in London and elsewhere.

To some extent this recurrent opposition was reasonable enough. The new forms of locomotion had dangers of their own; they were generally noisy and sometimes dirty; and occasionally, as in the case of early tramways, they were a nuisance to existing traffic. But it may be noted that electricity claims to provide a means of locomotion not only more rapid and more efficient (in most cases) than any other, but free from many of the drawbacks which gave conservatism an excuse for opposing the introduction of steam and other forms of locomotion.

In the following pages I hope to give a clear account of the achievements of electricity in the field of locomotion and also to indicate some of its more immediate potentialities.

CHAPTER II

EARLY TRAMROADS AND RAILWAYS

It has sometimes been remarked, by unfriendly critics, that tramways are an apology for bad roads. That is to say, if road surfaces were perfect, there would be no need to lay rails in order to allow vehicles to run easily.

Although this view of the case may be no better than a quarter-truth, it is justified to the extent that tramways were, as a matter of fact, the outcome of an attempt to escape from bad road surfaces. In the early days of mining, coals were taken by horse-drawn wagons from the pits to the harbours. The passage and re-passage of heavy vehicles on the same roadway led to the formation of deep ruts; and the first step towards both the tramway and the railway was taken when logs of wood or 'trams' were laid in the ruts to facilitate transport.

The next step was to make the upper surface of the log round and the rims of the wheels hollow, so that they fitted over the rails and kept the wagons

on the track. Owing to the upper part of the rails wearing away quickly, thin plates of iron were in some cases nailed to them. This improvement led to the adoption of a cast-iron rail, fastened to wooden sleepers.

The earliest cast-iron railway was laid down before the middle of the eighteenth century, about one hundred years after the first wooden 'tram-ways.' Half a century later we find the first rail-and-wheel combination as we know it on modern tramways and railways, where the wheel carries an inner flange and runs upon the head of a narrow metal rail. This is the form which experience has proved to be best adapted for safety, speed, and economy in power. The improvements made since the beginning of the nineteenth century have been in matters of detail.

Many miles of colliery tramroads were in existence when—at the beginning of the nineteenth century—the idea of using the steam engine in place of the horse was taken up by engineers. They were concerned at first solely with the carriage of coal; the idea of conveying passengers arose at a later date, after the steam automobile had been tried and abandoned for the time being. George Stephenson, for instance, ran his first locomotives on colliery tramroads; and the first railway—between Stockton and Darlington—was used for passengers merely as an afterthought. It was, in fact, designed to be a

tramroad for the use of the public in general transport by horse traction.

The most curious feature of this stage in the evolution of locomotion was that, although Stephenson's locomotives had been at work for several years and although several schemes of iron roads had been projected, very few people had any conception of the development awaiting the locomotive and iron road in combination. They did not even appreciate the proved fact that the locomotive was a more efficient means of transport than the horse. An immense amount of pioneering work had to be done before the impression of a new era could be borne in upon the public mind. These were the days when the *Quarterly Review* backed 'old Father Thames against the Woolwich Railway for any sum' and when a witness before a Parliamentary Committee (on the Liverpool and Manchester Railway Bill, in 1825) thought himself safe in suggesting that a steam locomotive could not start against a gale of wind.

When these prejudices were overcome, many years had to pass before the objections of landowners and citizens were worn down. Railway engineers spent most of their time in a form of diplomatic warfare with opponents to their schemes; huge sums—part of which still lingers in the capital accounts of railway companies—were spent in Parliamentary proceedings over Railway Bills. This barren process

had to be repeated when electric traction made its appearance; but happily the electrical fight was not upon quite so extensive a scale, nor was the period of preparation followed by anything comparable to the Railway Mania of 1845, when the public made up for its early contempt of railway enterprise by tumbling over itself to get shares in some of the most crazy schemes which were ever put into shape by unscrupulous company promoters.

The early history of the steam railway is interesting in connection with electrical locomotion for two reasons. It shows that the railroad proper evolved out of the tramroad or 'light railway,' as it would now be called—a type of line which is specially suited to electrical operation. It also includes a controversy between three modes of traction; and this controversy forms a very good introduction to a discussion of the reasons why electricity is so economical in locomotion.

These three modes were (1) stationary engines: (2) locomotives: (3) the device known as the 'atmospheric railway.'

In both the first and third, engine houses were placed close to the line at convenient intervals. In the first, each steam engine operated an endless rope to which the train of carriages was attached. The system is still in use for colliery working and is also employed (in an improved form, of course) for

funicular railways. George Stephenson himself employed it to assist locomotives up heavy gradients. In the atmospheric railway the stationary engines were used to exhaust the air from a length of cast-iron piping laid close to the railway. The principle is the same as that of the 'pneumatic tube' which the Post Office uses for sending papers over short distances. The papers are placed in a cylinder which fits the interior of the tube; and when the air is exhausted from the tube in front of the cylinder, the pressure of the air behind it drives the cylinder forward.

Nowadays it is difficult to realise that such a system was seriously proposed for railway work and actually adopted by an engineer of such eminence as Brunel. But in point of fact it was recommended by two Board of Trade experts in 1842 and by a Select Committee appointed in 1845 to consider several Bills for atmospheric railways. It was tried at Dalkey and Croydon, and it was installed under Brunel's supervision on a six-mile line in Devon. The carrier in the tube was connected to the train through a longitudinal slit at the top of the tube. The slit was closed by a leather flap, except when momentarily lifted by the passage of the train. A great deal of ingenuity was exhausted in attempting to make this 'longitudinal valve' efficient, but it was found that heat, moisture, and frost made the leather deteriorate

so rapidly as to render it hopelessly ineffective in a short time. After a series of misfortunes the atmospheric railway became a mere curiosity in the history of invention.

Stephenson was right in regarding the atmospheric railway as 'only the fixed engine and ropes over again, in another form.' He was also right in his belief that the steam locomotive was more economical than either of its rivals. But the stationary engine idea had the germ of an even sounder principle than that of the locomotive. Both in electric tramways and electric railways the power is obtained from stationary engines. The main difference between the electric system and the old rope and atmospheric systems lies in the superior economy with which the power is conveyed electrically to the trains. There are other important differences; but the essential point is that both rope traction and pneumatic propulsion wasted so much power between the engine and the train that their other advantages were annulled, and it was found cheaper to put the engine on wheels and make it drag itself as well as the train.

Brunel's reasons for his faith in the atmospheric railway are well worth quoting for the light they throw indirectly upon the advantages of electric traction. He argued that stationary power, if freed from incumbrances such as the friction and dead

weight of a rope, was superior to locomotive power, on the following grounds:

(*a*) A given amount of power may be supplied by a stationary engine at a less cost than if supplied by a locomotive.

(*b*) The dead weight of a locomotive forms a large proportion of the whole travelling load, and thus inherently involves a proportionate waste of power—a waste which is enhanced by the steepness of the gradients and the speed of the trains.

Experience has proved the soundness of these principles. There has been a steady improvement in the power and efficiency of locomotives, but progress has reached a point at which further increases in speed and accelerating power (a very important matter) are not attainable without a prohibitive increase in the consumption of coal and a costly strengthening of the railway track to stand the strain of heavier engines pounding along at very high speeds. Electric traction, which is a reversion in part to the stationary engine system, offers a means of escape from the limitations of the locomotive.

There is still some doubt in the minds of railway engineers whether electric traction is really superior to the steam locomotive on the main railway lines, where distances are great and train loads heavy. But the superiority is admitted on suburban lines and also on tramways, where electricity has almost