ELECTRIC STREET RAILWAYS.

A PAPER READ BEFORE THE CANADIAN ELECTRICAL ASSOCIATION BY E. CARL BREITHAUPT.

It is not intended to make this paper one of a purely technical nature; we shall endeavor rather to present a general review of the subject in hand and a systematic consideration of the problems and difficulties involved, omitting also detailed estimates of cost.

Until comparatively recent years street railways were operated almost entirely by animal power; steam engines of various forms were used, but the objections to the ordinary form of engine or dummy have confined them to the sparsely populated districts. Cable traction has come into extensive use, and lately also electric traction. Other methods are, however, also competing for public favor; in Toledo, Ohio, a plant was recently installed in which the motor was operated by compressed air, while another company in Chicago have been experimenting on the merits of compressed steam as motive power. In this system, water is to be heated at a charging station to a temperature corresponding to about 200 lbs. steam pressure, and each car is to have a well-jacketed reservoir to carry a supply of compressed steam and water; the motor is a small steam engine of special design to exhaust at a low pressure and operate noiselessly.

Electricity as a motive power for street railways possesses so many advantages over all other systems that it is at present recognized as the best method of propulsion for the great majority of cases. The speed of an electric car can be varied at will; power is consumed according to load and rate of speed, and there is no constant factor of loss as in the cable system; the cars can be moved forward or backward, they can be started and stopped with surprising rapidity, and are not liable to get beyond control. The system has also its points of inferiority; the method of transmitting current to the car by an overhead wire line is severely criticised, and the accounts furnished by the daily press of the accidents and destruction to life caused by the "deadly trolley" have come to be an old story, though in point of fact only a small proportion of these are attributable to purely electrical causes. The dangers of a street railway service naturally increase as the rate of speed maintained is advanced, and the greatest number of accidents are due to this cause. Cable railways are in reality a greater source of danger than is the line wire of a trolley road.

In electric railway work one of the chief problems involved is how to supply current to the moving motor. A number of different methods have been proposed, all of which resolve themselves into two distinct types, and since these affect changes in the entire operation of the road, we may classify the whole subject under the same headings, viz.:

1. Where the current is generated at a central station and transmitted directly to the car motor by means of a wire line and moving contact.

2. Where a certain quantity of energy is stored up in some form or other and carried on the car itself, there to be supplied in the form of electric current to the car motor. In this case the accumulator is usually an electric storage battery, though other plans have been proposed, in some instances very complicated.

In the first type the transmission of current may be accomplished by an entirely overhead line, or by an entirely underground line, or by a modification of these, as, *e.g.*, in the case of the Buffalo street railway, where, we believe, all the feeders and mains are buried and only the trolley wire is overhead. The term "trolley roads" may be applied to all of these. Theoretically considered, the second method is no doubt the more desirable one, since it eliminates entirely the difficulties of a transmitting line, but as yet it has not proven itself altogether successful; in fact the only electrical method which has so far stood the test of a number of years in all kinds of climate is the overhead trolley system of the first type.

The three essential points of any electric road naturally are:

1. The generating plant.
2. The transmitting plant.
3. The motors and car equipment.

Let us consider these more in detail.

GENERATING PLANT.

The location and design of the power station is a matter which should be studied with much care. For roads of the first type it should be as central as possible with reference to the territory covered, in order to economize copper and minimize losses on the line. If it be a steam plant it will be of advantage to place it where an abundant supply of water can be obtained for condensing, and near to railway lines and steamship wharves, so that fuel may be brought in without extra outlay for cartage. On the other hand, property values must also be considered; accurate estimates of all the quantities involved must be prepared, and to determine where it will be advisable to add to first cost in order to save in working expense, the interest on the extra capital so invested must be balanced against the decrease in working expense thereby effected. That it results in economy to utilize water power for electrical purposes cannot always be taken for granted. Such natural sources of power are generally found at locations more or less inconvenient, often at some distance from the centre of distribution, and the extra outlay for copper and other items of primary investment, as well as the increased loss in transmission may assume such large proportions as to bring the nc cost per horse power per year above what it would be if steam were used. Moreover, where the load is a variable one, the water power plant will not accommodate itself so well to the fluctuations, and the smoothness of operation obtained in a steam plant cannot be acquired; this entails a further loss as will be shown later.

In electric railway work of the first type, viz.:—Where the car motors are supplied with current directly from the generators by means of a transmitting line, the service required of the motive power is much more exacting than in ordinary cases; the load fluctuates between very wide limits and with great rapidity, particularly so on small roads. This causes not only unusual strains on the machinery, and which must all be allowed for in construction, but unless the regulating apparatus responds promptly to a change of load, satisfactory results cannot be obtained. Take for example a road operating six cars altogether, weight 8 tons per car, average speed 9 miles per hour, roadbed rather hilly but grades not over 3 per cent. The power required at the car axle to propel one of these cars on a level would be about 4 h.p., 2 per cent. grade 11.5 h.p., 3 per cent. grade 15.5 h.p. If now two of these cars be simultaneously started on ascending grades of say 2 and 3 per cent., while two others are running on