

between a single conductor and ground, as would be the case in the single phase system.

American engineers instead of endeavoring to adapt the unsuitable induction motor to traction purposes, have devoted their energies to the development of a suitable alternating current motor. The idea of using a series motor operated by alternating current is not new. The only alternating current single phase motors which have a characteristic suitable for electric traction purposes are those of the commutator type. In no other type of motor are the speed and torque characteristics such as to be suitable for traction purposes. In the commutator type alternating current motor, the speed and torque characteristics are practically identical with these characteristics in the direct current series motor. As early as 1893 extensive experiments were made by the Westinghouse Electric & Manufacturing Co. on this class of motors. In fact, the experiments went so far as to equip a car with two motors of this type and the car was put into actual operation. Moreover, the frequency and voltage for which the motors were designed was practically the same as those for which the more recent motors were designed. These early motors were considerably smaller in capacity, however, and the trolley voltage was less. Further, the method of controlling the speed was by control of voltage. Although the early motors were successful as motors, the alternating current system as a system was not thought at that time of sufficient importance to continue the developments along this line. In other words, the time was not yet ripe for the development of this system. Interurban electric traction work, such as exists to-day, was not at that time thought of, and this is, in the writer's opinion, the peculiar field for the alternating current traction system.

In considering the general problem of electric traction, the question naturally arises,—what is gained by the use of alternating current over direct current? and the converse of this question also naturally arises,—what is it necessary to sacrifice in order to obtain the benefit of alternating current traction? An analysis of the advantages and disadvantages of these two systems may be of interest. Although many of the following points have been treated in previous papers, particularly that of Mr. Lamme, acting chief engineer of the Westinghouse Electric & Mfg. Co., before the American Institute of Electrical Engineers in September, 1902, it is hoped that repetition of some of the points mentioned will not be out of order.

The principal advantages of the alternating current electric traction over the direct current are as follows:—

- (1). Limits to trolley voltage are removed.
- (2). Avoidance of rheostatic losses.