tinual change of speed is one of the characteristics of traction work. The direct current series motor is peculiarly adapted to this class of work because it is inherently a variable speed motor. At one definite speed the polyphase motor is an efficient machine, while at all other speeds the efficiency can not be greater than the ratio of the actual speed to the synchronous speed. For instance, if the actual speed at which a given induction motor is working is ten per cent. of its synchronous speed, the power utilized is at most only ten per cent. of the power put in. In traction work a large part of the work done is necessarily at speeds below the maximum attained, and at these lower speeds the maximum economy that can be obtained from induction motors is necessarily small.

One expedient used by European engineers to reduce this source of loss is the use of motors in concatenation or in tandem, that is, the secondary of one motor is fed into the primary of another on the same car. If the pair of motors thus concatenated are wound for the same number of poles, this expedient has the effect of making the synchronous speed of each of the pair of concatenated motors one-half that which it is when not in concatenation. It is equivalent in direct current practice to throwing two shunt motors in series. Up to the half speed joint, therefore, there is a gain of economy by this arrangement. By winding the two concatenated motors for different numbers of poles, more than one point of maximum economy can be secured between zero speed and full speed, but this arrangement has the disadvantage of being able to use but one-half the total motor capacity above half speed while the greatest expenditure of energy takes place above half speed. In order to secure the advantages of concatenation, however, it is necessary to add largely to the weight of the electrical apparatus. European practice has been to equip cars with four motors, two main motors and the other two being used only while the car is below half speed. Above half speed the motors are running idle and are doing no useful work. The energy required to take care of the additional weight is an offset against the energy which is saved by concatenating the motors. For long runs this expedient would probably be detrimental since the energy taken up to transport the extra weight would be more than equivalent to the energy saved at the start.

(2). The second reason against the use of polyphase induction motors for traction purposes is the necessity for providing at least two overhead conductors. If the track be not used as one of the conductors, then the necessity arises of using at least three overhead conductors. Maintenance of insulation on such overhead conductors when they are at high voltage is naturally a difficult problem, much more difficult than to maintain the insulation