

DISCUSSION ON "INDUCTION MOTORS FOR MULTISPEED SERVICE
WITH PARTICULAR REFERENCE TO CASCADE OPERATION."

ATLANTIC CITY, N. J., JULY 1, 1908

W. I. Slichter: There is a point in the subject of cascade connection of induction motors which the speaker would like to hear discussed, as it is particularly important in connection with railway engineering. The usual and first idea of the result of the cascade connection of induction motors is that it will make it possible to obtain from a given pair of motors a greater torque at a low speed than is obtained in normal operation. But a closer study of this subject shows that the maximum torque of two motors connected in cascade is always less than that of either one of the individual motors. This is a proved fact with regard to the operation of motors with like numbers of poles, but it would be interesting to know what the relation is with motors having different numbers of poles.

A. E. Averrett: I have found that, in general, concatenated coupling, when used for a very small range of speed, will work out quite nicely, as it is comparable to a relatively small change of voltage, with a compensator or autotransformer, but as the range of speed increases, the effectiveness of the concatenated set decreases. The second motor has all its power carried through the first motor, and the first motor will have a great impedance drop, so that the effective voltage of the second motor, after the current has passed through the impedance of the first motor, is low. Furthermore, the concatenated motor acts similarly to a single two-speed motor. The lower the speed of any induction motor, the lower the power-factor; that is, in case the speed reduction is by a change of poles. A constant-speed, collector-ring, induction motor will maintain approximately constant torque with an efficiency in proportion to the speed; a concatenated or multispeed motor, where the change of speed is made by shortening the pole pitch, will maintain fairly constant efficiency, but the power factor goes down with the speed reduction. In concatenated motors the problem is nearly as much a mechanical as an electrical problem; the diameters become small, distances between bearings centers increase, and with the slow speed which we are really trying to maintain, the question of ventilation becomes important. There was recently built a concatenated set for a very peculiar service, rolling mill work, where the concatenated motors were 20 and 16 poles, and the combination 36 poles. It happened that the power required for the actual concatenation work, at 36 poles, was very slight, the main power being at the 20- and 16-pole speeds.

Most motor work will require constant torque or perhaps torque increasing as the speed drops (constant power). In these cases, the low power-factor of the concatenated motor renders it extremely difficult to make a good combination at the

low speed; but for a close range to the normal speed, as before stated, the concatenated motor works very well.

Elmer A. Sperry: Can anybody here throw light on the subject of returning power to the line when this class of motor is employed in traction service, coupled as described?

H. C. Specht: It has been asked if two motors connected in cascade would give any more torque than one of the motors. This certainly is not possible unless auxiliary devices are used. The motors connected in cascade will have somewhat less, or

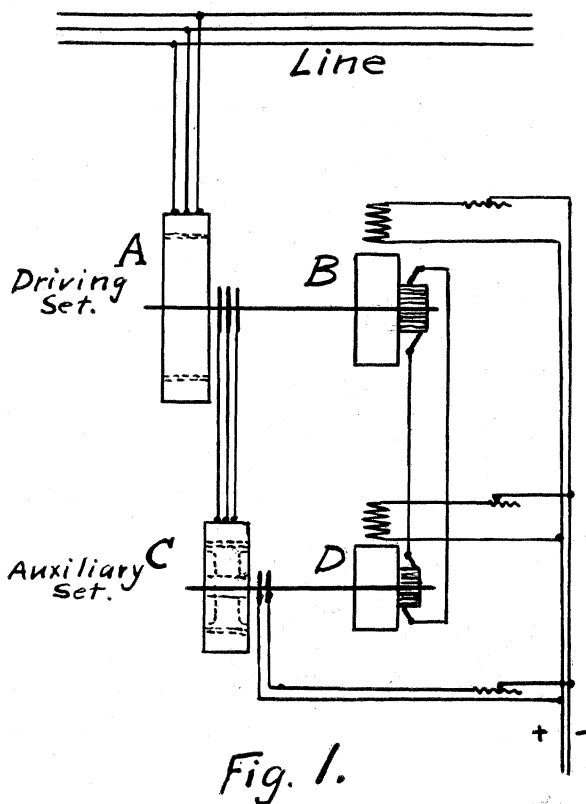


Fig. 1.

not more torque, than the average of the two motors, and the reason is simply that the current has to pass through both motors, which increases the leakage. As was mentioned at the end of my paper, it is a problem of finding a good phase compensator, to eliminate the most objectionable features of cascade connections.

In regard to compensated cascade sets, I would like to mention that several schemes have been suggested in the last few years. Whether or not any of these schemes will be adopted

for general use and give satisfactory results, is yet an open question.

The method generally used for compensation is that of connecting a synchronous motor or a compensator induction motor in the secondary circuit. The motors are then regulated so as to produce a leading current. Since this current, with the primary current and the magnetizing current of the main motor, form a triangle, it is possible to raise the power-factor not only to one but to obtain an over compensation or leading current.

The following will serve as examples of the methods referred to and as described recently by Heyland, Willner, and Kubler in German technical periodicals.

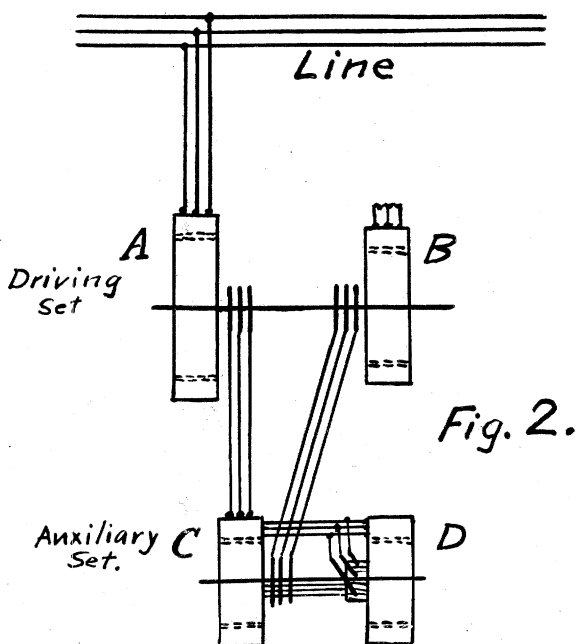


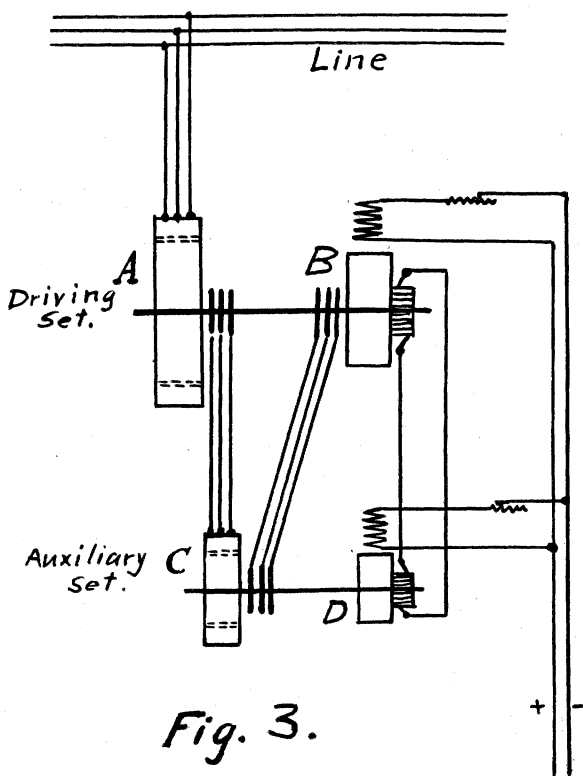
Fig. 1 shows an arrangement with a synchronous motor (C) in the secondary circuit. On the same shaft with the latter motor is a direct-current generator which supplies current to the second driving motor (B), which is, in this case, a direct-current motor. The direct-current machines and the synchronous motor are excited from a separate direct-current circuit.

In Fig. 2, compensation is accomplished by means of a compensated induction motor (D) connected to the secondary circuit of the main driving motor and to the other induction motor (C), which latter is mounted on the same shaft as the compensated motor, and serves as a frequency changer.

The second driving motor (*B*) is also an induction motor and is connected to the secondary circuit of motor (*C*).

In Fig. 3 is shown a method similar to that in Fig. 1, with the exception that the synchronous motor (*C*) is replaced by an induction motor, the secondary of which is connected through the collector rings to the armature winding of the driving motor (*B*).

The foregoing methods serve not only to compensate the power-factor, but also allow of starting up the tandem set



with a great deal less kilowatt input than would be required in the case of ordinary induction motors, on which a great deal of power is wasted on the secondary resistance. It likewise increases the maximum running torque over that of an ordinary cascade set.

In addition, the schemes as shown in Figs. 2 and 3, permit of reversing the set in a comparatively short time and with no sudden rush of current, as the inertia in the two driving motors is kept small. The flywheel on the auxiliary motors serves as a

storage for kinetic energy. For obvious reasons these latter should be designed for high speed.

Further, we see that the methods above described allow of running tandem sets at variable speeds with the minimum waste of energy. In some respects they are similar to the Ilgner & Leonard reversing systems.

The method as shown in Fig. 3 would seem to contain possibilities in connection with hoisting, rolling-mill, and traction service.
