tarding torque or load. It is thus seen that while this type of machine has no direct starting torque, it will carry a load proportionate to other machines when it has once reached a certain speed. Since each conductor passes two poles for each cycle of the current, it follows that the revolutions per second must be

$$n = \frac{f}{p} \quad \dots\dots\dots\dots (32)$$

From the above it follows that any alternating current generator will run as a synchronous motor, and that its speed when operating will depend entirely on the frequency of the supply voltage and the number of its poles. If the frequency is constant the speed will be constant at all loads. If the retarding torque is increased until it is greater than can be overcome by the motor, the latter will stop at once, and the driving torque will fall to zero. In such an event the motor would be automatically disconnected from the line by a circuit-breaker or some other protective device. This would prevent it from being injured by the excessive current which would flow through its armature when at rest.

As this type of motor has no direct starting torque, some auxiliary means or artifice must be adopted to start it and accelerate it to synchronous speed. When a large torque has to be overcome in starting, as in cases where there are long lines of shafting, it is usual to use a

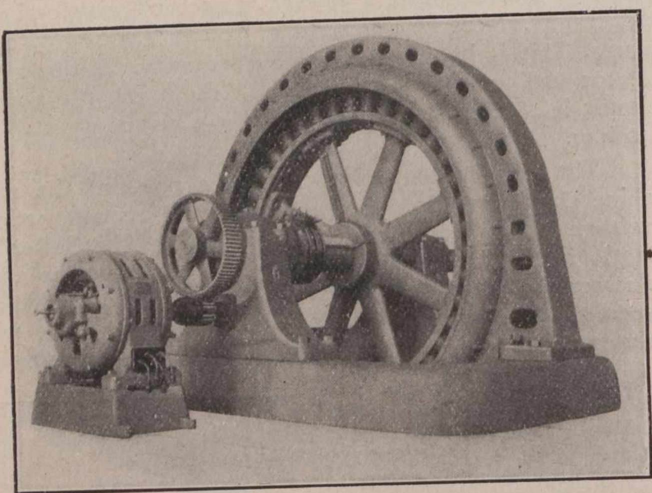

Fig. 66.

friction clutch, by means of which the load may be gradually thrown on the motor after it has reached synchronous speed. The motor itselfmay be started by various methods. One method is to apply part or all of the line voltage to the armature with the poles unexcited. The alternating flux set up by the armature current will induce eddy currents in the ends of the poles which will react on the flux and give a small starting torque. When the maximum speed is reached (this will be a little below synchronism) the exciting current is turned on. This will bring the armature quickly into synchronism. The full load may then be gradually thrown on. The objection to this method is the disturbance on the line caused by the excessive current taken at starting. If the full voltage is applied to the armature the starting current will be one and a half to several times the normal full load current. Another method of starting is to use a small auxiliary motor of the induction type (to be discussed later). If the motor can be started without any load a starting motor of about one-eighth the capacity of the synchronous motor is usually sufficient. In this case the current taken from the line at starting is about one-third the normal full load current of the motor. When this method is used the speed must be brought exactly to synchronism with the motor voltage and the line voltage exactly opposite in phase before the motor can be connected to the line. A special instrument, known as a "synchroscope" or "synchronizer," is used to indicate when these conditions are secured. A large motor of the "revolving field" type, with an induction motor geared to it for starting purposes, is shown in Fig. 66.

The direct current which is required to excite the poles of a synchronous motor or an alternating current generator is usually provided by a small auxiliary direct current generator called an "exciter," except in cases where some independent source of direct current is available. The exciter may be driven by an independent prime mover or belt connected to the shaft of the machine which it excites.

It has been noted above that the speed of any particular synchronous motor varies only with the frequency of the supply voltage. As this is practically constant, if the excitation is increased the generated e.m.f. will increase in proportion to the increase of flux. The e.m.f. may thus be increased until it exceeds the supply voltage, in which case the current taken by the motor will be ahead of the supply voltage in phase. The synchronous motor may thus be made equivalent to a circuit with either positive or negative inductance simply by varying its excitation. It can, therefore, be made to operate with unit power factor at all times by adjusting the excitation so that the current is in phase with the line voltage, and if it is operating in parallel with inductive apparatus it can be made to take a leading current, which will neutralize the lagging current taken by the inductive apparatus. In other words, a synchronous motor may be used to improve the power factor of a system. It is this characteristic, not possessed by other types of alternating current motors, which makes the synchronous motor desirable under certain conditions, notwithstanding the difficulties in starting.

This type of motor is not suitable where the load is subject to heavy and rapid fluctuations or where there is a possibility of heavy momentary overloads. In either case the motor might fall "out of step" and stop.

The synchronous motor is cheaper to build than other types of alternating current motors, and its efficiency is usually higher.

PORTLAND CEMENT IN QUEBEC.

The manufacture of Portland cement is one of the most flourishing in the Province of Quebec. For the year 1909 the Mines Department of Quebec records a marked increase over 1908.

The chief feature of this industry in 1909 was the merging of the various companies manufacturing cement in the province into an association whose influence was a national character. In fact, the Canada Cement Company has acquired the three large cement factories of our province, together with several others in the Provinces of Ontario, Alberta and British Columbia. It is expected that the result of this amalgamation will be a considerable saving in the cost of management and especially of transportation, by which consumers will certainly benefit.

The manufacture of cement has made remarkable progress for some years past. Previous to 1904 there was but one factory in operation, whose production varied between 25,000 and 40,000 barrels a year. In 1905, the International Cement Company, of

(Continued on page 202.)