citing coils as in the case of the direct current generator. Consider now the e.m.f. generated in one conductor, say, c_1. As this conductor passes pole No. 1, cutting lines of force, the e.m.f. generated in it will be from front to back of the machine as it is viewed in the figure. As it passes pole No. 2 the e..mf. generated will be in the opposite direction. As this conductor continues in its path, this reversal of e.m.f. continues indefinitely. The e.m.f. generated in each conductor is thus an alternating one, and passes through a complete cycle of changes as the conductor passes one pair of poles. If **p** represents the number of pairs of poles, **f** the frequency and **n** the revolutions per second,

$$\mathbf{f} = \mathbf{pn} \qquad (31)$$

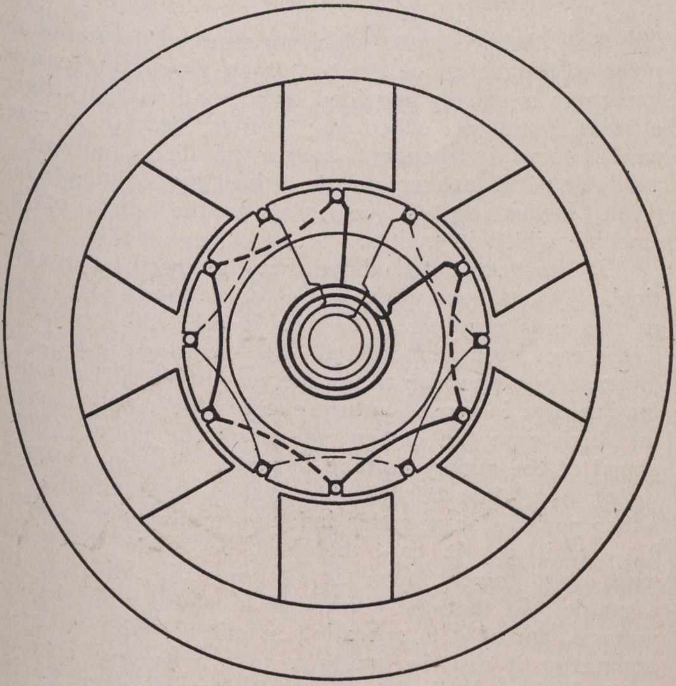

FIG. 64

This applies to every conductor on the armature. At any instant, however, the direction of the e.m.f. in one half of the conductors is opposite to that in the other half, but the conductors may be connected so that all the e.m.fs. act in one direction around the circuit. The total e.m.f. will then be equal to the e.m.f. generated in one conductor multiplied by the number of conductors. While there is only one conductor per slot shown in the figure, there may be any number in each slot, and all connected so that the e.m.fs. act in one direction in the circuit.

Suppose, now, that a second set of conductors is placed midway between those of the first set, as shown in Fig. 64, and that these are connected in series the same as the first set, the ends of the circuit so formed being connected to a second pair of rings. It is obvious that there will be generated in this second circuit an alternating e.m.f. of the same magnitude and frequency figure. As it passes pole No. 2 the e.m.f. generated will differ in phase by 90°. Any machine of this kind is known as a "two-phase" generator. If instead of two sets of conductors there are three sets symmetrically placed on the armature, three e.m.fs., differing in phase by 120° will be obtained. A machine with its armature winding arranged in this way is known as a "three-phase" generator. The methods of connecting the three circuits of a three-phase generator to the collecting rings are shown in Figs. 59 and 60a.

Referring to Fig. 63, it will be obvious that the e.m.f. may be generated in the conductors by revolving the armature, or by keeping the armature stationary and revolving the poles. In most modern generators the latter system is adopted, the poles being placed on the internal revolving structure and the conductors on the inner surface of the external stationary structure In this case the exciting current has to be conducted to the exciting coils through brushes and collecting rings, while the armature circuit (or circuits), being stationary, connect directly to the external circuit. The two parts of a machine of this type are shown separately in Fig. 65. The advantages of this "revolving field" type of generator are: (1) The armature conductors are stationary, and can, therefore, be more easily insulated. (2) The collector rings and brushes have to transmit only the current required for excitation, and this at low voltage. (3) The poles and exciting coils constitute a fairly effective flywheel for the machine.

Rating of Alternating Current Generators.—The capacity or rating of an alternating current generator is the amount of power which it can deliver continuously to a non-inductive circuit ($\cos \phi = 1$) without overheating. For example, a 50 k.w., 1,000 volt, single-phase generator will carry a current of 50,000/1,000 = 50 amperes. This is its current-carrying capacity. If this generator delivers power to a circuit of which the power factor is .8, its output will be $W = 1{,}000 \times 50 \times .8 =$ 40 k.w.

The Synchronous Motor.—If the poles of the machine shown in Fig. 63 are excited and an alternating voltage is applied to the armature when the latter is stationary, a force will be exerted on the armature conductors which will tend to rotate the armature, but as soon as the current changes in direction the force will change and tend to rotate the armature in the opposite direction. The average force will be zero, and there will be no motion. If, however, the armature is rotating at a speed such that each conductor moves a distance equal to the pole pitch in the same time as the current changes from maximum positive to maximum negative, there will be a simultaneous change of current and direction of field acting on each conductor. There will consequently be no change in the direction of the force. The armature will, therefore, continue to rotate in synchronism with the current, and it will overcome a re-

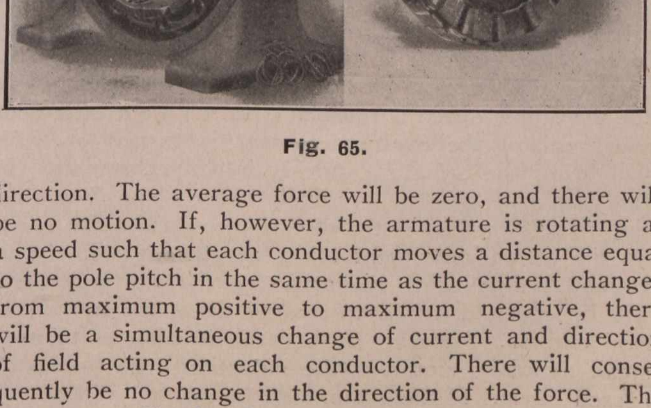

Fig. 65.