of synchronous motor drives, listing starting, pull-in, and pull-out torques.

Typical specifications for synchronous motors are shown in Table 7.

Multi-Speed motors provide flexibility in many types of drives. Synchronous motors can be furnished only with a 2 to 1 ratio in speed, single winding. Squirrel-cage induction motors may be 2, 3 or 4 speed. Two-speed induction motors are usually of single winding type, having a 2 to 1 speed ratio such as 600 rpm and 1200 rpm, or may be double winding. Three-speed induction motors are always two winding, and four-speed motors are usually two winding with a 2 to 1 speed ratio in each winding.

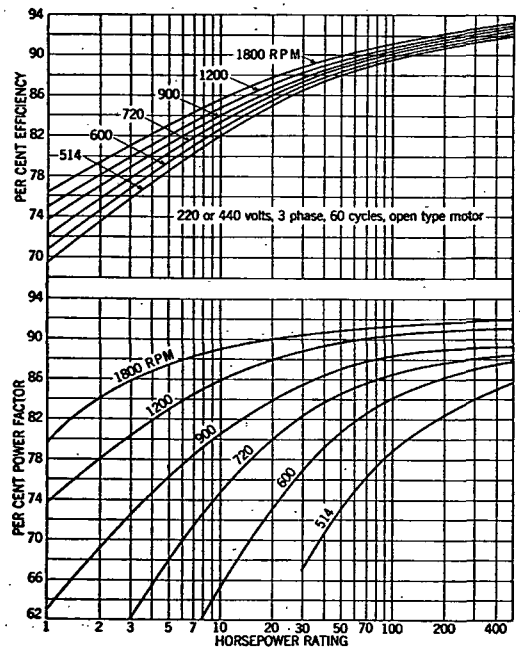

FIG. 8. EFFICIENCIES AND POWER FACTORS FOR SQUIRREL-CAGE INDUCTION MOTORS

Motors can be provided in constant torque, varying torque, or constant horsepower ratings. The constant horsepower type of motor is considerably larger than the constant torque motor due to the fact that the same horsepower must be developed at either reduced speed or high speed.

In selecting two-speed motors for fan, pump, blower, or compressor applications, it is usually found that two winding motors are more expensive than the single winding type. The control cost for two-speed, two winding motors, however, is more economical, and therefore the combined price of both motor and control for the two winding motor is only slightly higher. Because of the improved performance of the two winding motors and because of the factor of safety provided by two independent windings, the increased cost is frequently worth the difference.

Single Phase Motors

Single phase induction motors have auxiliary windings or devices for starting and are classified by the method used.

Capacitor start motors develop high starting torque in fractional hp ratings and moderate starting torque in larger ratings. They are used for constant speed drive such as fans, blowers and centrifugal pumps. During the starting period, a winding with a capacitor in series is connected to the motor circuit and when the motor comes up to speed a centrifugal switch cuts the capacitor and second winding out of the circuit.

Two-value capacitor motors develop high starting torque employing a starting capacitor and a running capacitor. The starting capacitor gives high starting ability but is suited for short time operation only and is cut out for the running condition by a centrifugal switch. The running capacitor gives high efficiency at full speed. These motors are used on compressors, reciprocating pumps and similar equipment which may start under heavy load.

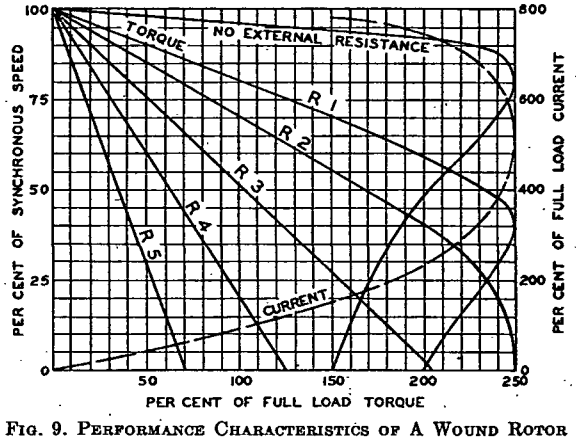

FIG. 9. PERFORMANCE CHARACTERISTICS OF A WOUND ROTOR MOTOR WITH EXTERNAL RESISTANCE

Permanent split capacitor motors have low starting torque and are ideally suited for small fan drives. Operation is similar to the capacitor start motor except that the capacitor is not cut out when running.

Repulsion-Induction motors develop high starting torque. The motors have two rotor windings—a squirrel cage for running and a wound rotor connected to a commutator for starting. No switching device is required to change from starting to running winding as this is accomplished by a gradual shift with speed in the magnetic flux path so that near rated speed the squirrel cage winding has taken over completely.

Repulsion Start-Induction Run motors are similar to the repulsion-induction motor except they have only the commutator winding. They are supplied with a centrifugal short circuiting switch which shorts the commutator bars when the motor comes up to speed to obtain a winding approximately like the squirrel cage in its function.