sacrifice is made for the other speed and operating characteristics approaching single winding motors may be expected.

Frequently, multispeed motors lend flexibility to an installation that cannot be obtained in any other way.

Multispeed motors are started directly across the line through magnetic starting equipment with overload and low voltage protection and may have compelling relays to insure starting on low speed regardless of the ultimate running speed. Starting on low speed limits the starting current to the starting current of the low speed winding and consequently lowers the maximum demand.

Often where the central station requires current limiting starting equipment for the normal torque, normal starting current motor, it is advisable to use the normal torque low starting current multispeed, or the wound rotor motor. High slip polyphase motors may be used for adjustable varying speed drives in a manner similar to that described for

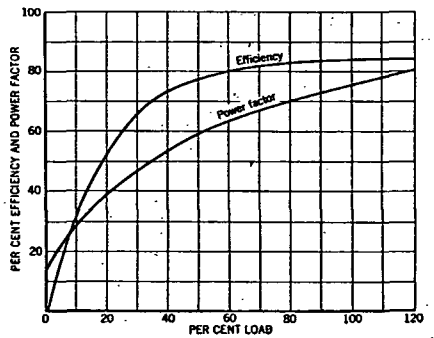


FIG. 4. VARIATION OF EFFICIENCY AND POWER FACTOR WITH LOAD FOR SQUIRREL-CAGE INDUCTION MOTORS

capacitor motors, with either a transformer speed regulator or tapped motor windings.

The approximate full load efficiencies and power factors for general purpose normal torque, normal starting current squirrel-cage induction motors are shown in Fig. 3. The change of efficiency and power factor of a typical normal torque, normal starting current squirrel-cage induction motor with load is illustrated in Fig. 4. The efficiency of a normal torque, low starting current motor is essentially the same as shown in Fig. 3 and the power factor slightly lower. For the high torque low starting current motor the efficiency is considerably lower than Fig. 3 and the power factor slightly lower than shown. It is apparent from these motor characteristics that a squirrel-cage motor may be selected for operating any air conditioning and allied equipment.

Some *polyphase induction* motors are constructed with two windings on the rotor, one of which is a high resistance, squirrel-cage winding used in starting and gives a high starting torque approximately the same as the high torque, squirrel-cage. A centrifugal mechanism within the motor switches to the second low resistance winding when the motor

comes up to speed, thus obtaining running characteristics equal to the normal torque, normal current squirrel-cage motor. The starting power factor of the motor is high.

Wound rotor motors are built for two classes of service, constant speed and adjustable variable speed. The motors are identical in each case and use the same primary control, the only difference being in the secondary control. Wound rotor motors for constant speed service are used where high starting torque with low starting current is required for bringing heavy loads up to speed. The resistance is in the secondary or rotor circuit, only when starting, and is short circuited when the motor is up to speed.

For adjustable varying speed service, part or all of the secondary

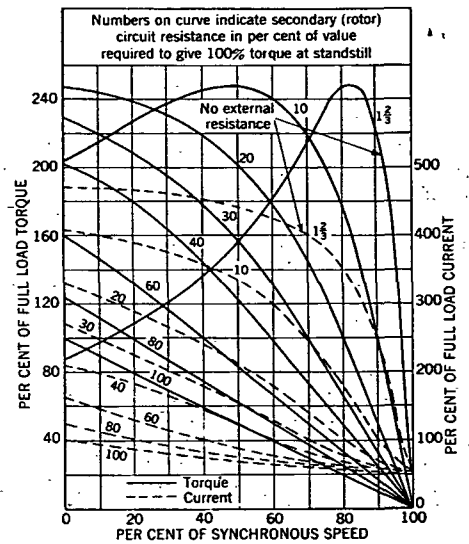


FIG. 5. PERFORMANCE CURVES FOR WOUND ROTOR MOTOR WITH DIFFERENT EXTERNAL RESISTANCES

controller resistance is in the circuit whenever the motor is operating below full speed. The speed obtained with a given resistance in the secondary circuit is dependent on, and changes within limits, with the load on the motor. The horsepower developed by the motor driving a load requiring constant torque, such as a reciprocating compressor, is approximately proportional to the speed, whereas the power input required by the motor is practically the same at reduced speed as at full speed. Hence the efficiency at reduced speed is much lower than at full speed. For such a motor the minimum speed is approximately 50 per cent of the full load speed. For loads whose torques decrease with speed, such as fans and blowers the horsepower developed is approximately proportional to the cube of the speed and the power input to the motor is reduced with decreased speed. However, the efficiency is lower than full