varying speeds through line voltage control. The motors are ideally suited for fan duty.

Speed-torque characteristics of single phase motors are shown in Fig. 3.

Full voltage starting of single phase motors is general practice, but since most of these motors are connected to secondary distribution systems located in light load density areas, power companies check carefully the starting currents in order to prevent objectionable voltage dips. This is particularly important for motors started frequently, such as those controlled by pressure or temperature sensitive devices and applied to refrigerators, stokers, oil burners and water pumps.

The report of a joint committee of *AIEC-EEI-NEMA** recommended three application rules taking into account the greater annoyances resulting from frequent motor starting during lighting hours against infre-

TABLE 6. RECOMMENDED SINGLE PHASE MOTOR RATINGS FOR FULL VOLTAGE STARTING

HP RATING	LOCKED-ROTOR CURRENT[a] AT 25 C Amperes		GENERAL USE (Rules 1 & 2)		SPECIAL CONDITIONS (WITH UTILITY PERMISSION) (RULE 3)	
	115 V	230 V	115 V	230 V	115 V	230 V
1/20	20	10	A-M	A-M	A-M	A-M
1/8	20	10	A-M	A-M	A-M	A-M
1/6	20	10	A-M	A-M	A-M	A-M
1/4	23	11.5	A-M	A-M	A-M	A-M
1/3	31	15.5	M	A-M	A-M	A-M
1/2	45	22.5	M	A-M	A-M	A-M
3/4	61	30.5		M	A-M	A-M
1	70	35		M	A-M	A-M
1 1/2		40		M		A-M
2		50		M		A-M
3		70				A-M
5		100				

A refers to automatically controlled devices.
M refers to manually controlled devices.
[a] These values of Locked-rotor current are the same as the *NEMA* standard for single-phase Design M motors.

quent starting at any time. Table 6 shows typical applications of these rules which are becoming widely accepted for full voltage starting. Rules 1 and 2 apply to general use.

Rule 1 limits the locked-rotor current to 20 amp at 115 volts, and 25 amp at 230 volts when automatically controlled (usually frequently started) motors are used. Rule 2 permits twice these values when manually controlled (usually infrequent starting) motors are used. Rule 3 applies to special conditions where larger currents may be allowed above Rules 1 and 2 upon approval of the electric company.

Hermetically enclosed single-phase a-c motors are widely used in appliances such as domestic and commercial refrigerators, room air conditioners, beverage coolers, freezer chests, and water coolers. In such appliances, the motors are sealed inside the compressor, and the gas and oil circulate freely within and around the motor. Centrifugal starting switches are not used on such motors because any arcing in the gas and oil atmosphere would be detrimental, and also because the units are permanently sealed and cannot be serviced or repaired in the field. In place of a centrifugal switch, an external relay is used to start hermetically enclosed motors.

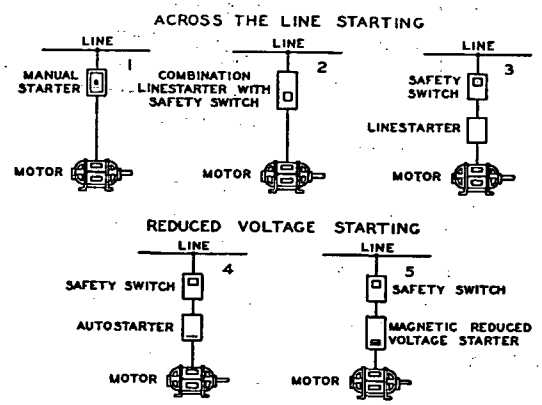
Hermetically enclosed motors for refrigeration compressors will, in the future, have the horsepower rating eliminated. The full load current is

* Refer to Glossary at end of chapter.

to be the operating current in amperes, when the compressor is delivering rated output.

The motors for hermetically enclosed service are usually of the split-phase type or of the capacitor-start (or two-value capacitor) type.

For starting the split-phase type of motor, two methods are generally acceptable. In one method a thermally-operated time delay is used. When the motor is started, a contact which is normally closed applies power to the starting winding. A thermal element which controls these contacts is in series with the motor and carries line current. Due to the current flow through this element, it is heated until, after a definite period of time, it is warmed sufficiently to open the contacts and remove power from the starting winding. The running current then heats the element enough to keep the contacts open. The setting of the time for the starting contacts to open is determined by tests on the system components, *i.e.*, the relay, the motor, and the compressor, and is based on a prediction of the amount of time delay required to bring the motor up to speed.



Arrangements 2, 4 and 5 provide automatic push-button starting.

FIG. 4. RECOMMENDED CONTROLS FOR SQUIRREL-CAGE MOTORS

The second method of starting split-phase motors utilizes a series-coil or current-operated relay. This device is affected indirectly by motor speed.

In this type of connection, a relay coil carries the line current going to the motor. When the motor is started, the inrush current to the running winding, passing through the relay coil, causes the contacts to close, and applies power to the starting winding. As the motor comes up to speed, the current decreases until at a definite calibrated value of current corresponding to a pre-selected speed, the magnetic force of the coil diminishes to a point which allows the contacts to open, removing power from the starting winding.

Capacitor-start and *two-value capacitor hermetically sealed* motors are usually started with a voltage-type relay. In this method of starting the relay coil is connected in parallel with the starting winding. When power is applied to the line, the relay does not operate because it is calibrated to operate on a higher voltage. As the motor comes up to speed, the voltage across the starting winding and relay coil increases in proportion to the motor speed. At a definite voltage corresponding to a pre-selected speed, the relay operates and opens its contacts, thereby opening the starting