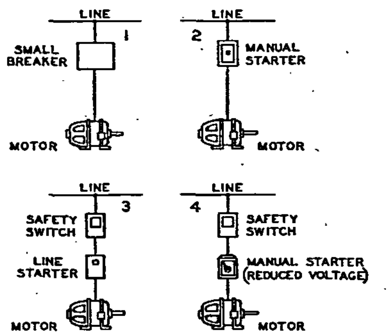
and automatically accelerate to the desired speed. Decelerating relays may be used to reduce the shock effect of the braking action on the motor and drive when the speed is reduced from a higher to a lower speed.

Single Phase motor control usually consists only of a linestarter, either manual or magnetic. In some cases it is desirable also to provide a disconnect switch. Fig. 15 illustrates the recommended controls.

Typical specifications for single phase motor control are shown in Specification J at end of chapter.

GEAR MOTORS

A gear motor is a self-contained combination of any type of a-c or d-c motor and an enclosed speed-reducing gear, providing a more compact and readily adaptable unit than is obtained by using a motor coupled to a gear reducer. Gear motors are available in sizes up to 75 hp with output shaft speeds from about 4 to 1430 rpm, making it possible to couple or to connect by gear or chain to nearly any machine. High speed motors are used, generally 1800 rpm on 60 cycles, thus obtaining the advantages of high motor power factor and efficiency. The gearing efficiency is also high, usually about 98 percent for a single reduction of the helical or spur type, that is, a 2 percent loss for one reduction or 4 percent loss for a double reduction. Consequently, the overall performance of the gear motors is much higher than a combination of open gearing, belting, countershaft, or other arrangement, which would otherwise be required. Gear motors are used extensively to drive numerous types of slow speed drives. Besides being more effective than other combination drives in saving space, they are important in reducing maintenance and operating hazards.



Arrangements 2, 3 and 4 are optional for motors up to 7½ hp, 220 volts.

FIG. 15. RECOMMENDED CONTROLS FOR SINGLE PHASE MOTORS

MOTOR RATING

The rating of an electric motor depends upon the total temperature which the motor attains under operating conditions. This total temperature depends on both the ambient temperature and the temperature rise of the motor. As motor temperature rise is in turn determined by the ability of the motor to dissipate heat, circulation to the motor should not be restricted. Improper selection of motors with regard to temperature ratings may result in high motor operating temperatures with accompanying reduction in motor life.

In general, the electrical insulation is the portion of the motor most susceptible to injury from high operating temperatures. Of the several types of insulation which are available, the most common type, specified as Class A by the *National Electrical Manufacturers Association*, consists of cotton, felt, paper or similar organic materials, and permits a 55 C rise in temperature over a 40 C ambient temperature for totally enclosed motors. Class B insulation consists of mica, asbestos, fiber glass, or similar inorganic materials, and permits a 75 C rise in temperature over the 40 C ambient for totally enclosed motors. Other types of insulation, such as silicone resin, are available and permit much higher operating temperatures.

The mechanical construction of the different types of motor enclosures, and the rise in temperature with Class A insulation for each type, are enumerated in the glossary at the end of this chapter. Since the difference between the hottest spot and the maximum observable temperature, as measured by a thermometer, is greater for an open machine than for an enclosed machine, the permissible temperature rise is 50 C for an open motor.

FUNCTIONS OF CONTROL EQUIPMENT FOR MOTORS

In general, control equipment for all types of motors should provide: (1) means of disconnecting the motor from the power supply; (2) means for starting the motor; (3) overload protection for the motor; (4) protection against low voltage; and (5) means for varying the motor speed.

Full voltage starting for motors is preferable because of its lower first cost and simplicity of control. Except for d-c machines, most motors are mechanically and electrically designed for full voltage starting. The starting inrush current, however, is limited in many cases by regulations of power companies because of the voltage fluctuations which may be caused by heavy current surges. It is therefore often necessary to reduce the starting current below that obtained by across-the-line starting. The power supplier should be consulted to determine the allowable inrush current for any given location.

The choice between full voltage and reduced voltage starting is governed almost entirely by inrush current limitations. The starting torque of all motors varies with the starting current, and it is therefore necessary to insure that the motor is supplied with sufficient current to develop enough torque to accelerate the load.

In present practice overload protection of motors is obtained by use of thermal overload inverse time limit type protection. The usual setting of such protection devices is not to exceed 125 percent of rated full load current for open 40 C rise motors, and not to exceed 115 percent of rated full load current for all other motors, the element tripping after a definite interval of time. The National Electrical Code requires the addition of fuses or circuit breakers to protect the overload elements from severe short circuit currents.

Two types of protection are available against low voltage at the motor terminals. One type, called low voltage release, permits the motor line contactor to drop out on low voltage and to close again when the voltage returns to normal, thereby restarting the motor when the abnormal condition is ended. The second type, called low voltage protection, causes the