winding circuit. The relay then keeps these contacts open because there is sufficient voltage induced in the starting winding, when the motor is running, to hold the relay in the open contact position.

CONTROL FOR ALTERNATING CURRENT MOTORS

Squirrel-Cage motors are usually linestarted where power company limitations permit. In sizes up to 5 hp at 220 volts, or 7½ hp at 440 volts, polyphase motors may be started by means of manual switches having overload current elements for motor protection. In larger ratings a linestarter is usually provided with either an additional safety switch or circuit breaker for disconnecting and short circuit protection. Reduced voltage starting may be either of manual or push button controlled magnetic type. In specifying this type of starter, consideration should be given to the fact that starting torque of squirrel-cage motors varies as the square of the applied voltage. For example, a motor developing 100 lb-ft starting

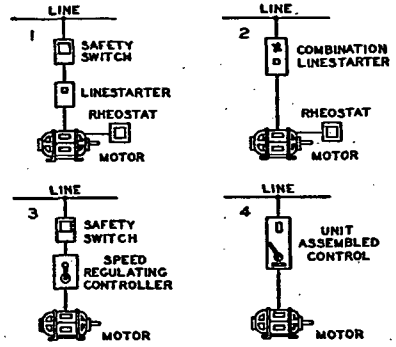


FIG. 5. RECOMMENDED CONTROLS FOR WOUND ROTOR MOTORS

torque on full voltage would produce only 25 lb-ft torque on starting on half rated voltage. Fig. 4 illustrates recommended control practice for squirrel-cage motors.

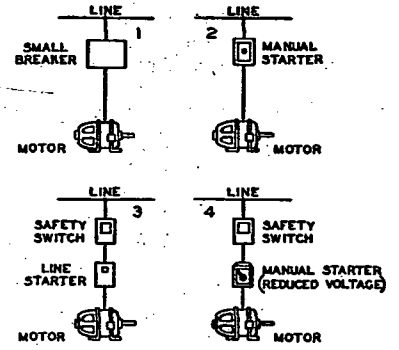
Wound Rotor motors require control of both primary and secondary circuits. The primary* control may be the same as for squirrel-cage motors, manual or magnetic, at full voltage. Secondary* control provides means of varying secondary resistance for starting and speed control. The secondary controller should be specified for starting duty only, or for speed regulating duty. If the secondary controller is to be used for speed regulating duty, the percent speed reduction, the number of speed control points, and the type of load (variable or constant torque) should be specified. Fig. 5 illustrates recommended control practice for wound rotor motors.

Synchronous motor starters should provide pull-out protection, automatic synchronization or automatic stopping of the motor after pull-out, and insurance of complete starting sequence, as well as overload and low voltage protection. The control may be either magnetic or semi-magnetic at full or reduced voltage. Semi-magnetic starters provide automatic field control, but require hand operation for closing the line contactors to start and transfer to full voltage.

* Refer to Glossary at end of chapter.

In applying reduced voltage starters to synchronous motors it should be remembered that, since these motors are started on damper windings and function during the acceleration period similarly to squirrel-cage motors, the starting torque varies as the square of the applied voltage. Consideration should be given to insure development of sufficient motor torque to accelerate the load.

Multi-Speed control may be either manual or magnetic, and at full or reduced voltage. When using automatic magnetic control with two-, three-, and four-speed separate winding or consequent pole motors, control may be obtained from a remote point by means of a push button master switch. The various speeds of the motor are obtained from the master switch by simply depressing the correct push button. This is known as selective speed control. It is commonly used in the smaller theater installations where the fan and motor are located backstage and the speed control is located in the lobby.



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

FIG. 6. RECOMMENDED CONTROLS FOR SINGLE PHASE MOTORS

Multi-speed motor controllers may be provided with compelling relays which make it necessary for the operator to press the first speed button before regulating the motor to the desired speed. This insures that the motor is always started at low speed before adjusting to a higher speed.

Timing relays which provide for automatic acceleration may be used for control. With this feature the motor will always start at low speed 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. 6 illustrates the recommended controls.

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