ping after a definite interval of time. The National Electric 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 motor line contactor to drop out on low voltage but prevents restarting when the voltage returns to normal except by the action of an operator. This latter type of protection is desirable where it is necessary for the operator to make initial starting adjustments on the machine.

Manual control for an alternating or a direct current motor is usually located near the motor. When so located an operator must be present to start and stop or change the speed of the motor by operating the control mechanism. Manual control is sometimes employed only as a device to give overload protection and another device is employed to start and stop the motor. Manual control is used particularly on small motors which operate unit heaters, small blowers, and room coolers in an air conditioning system. In other cases manual control in the form of drums, when used with multi-speed motors, is only used as a speed setting device while the starting and stopping functions operate automatically through thermostats and pressure switches.

Because of the increasing complexity of air conditioning systems, the equipment is operated preferably by automatic control and less dependence is placed on manual operation and regulation.

Automatic control of motor starters may be accomplished by the use of remote push button stations, by a thermostat, float switch, pressure regulator, or other similar pilot devices. An added advantage of automatic control is that the main wiring for the starter may be installed near the motor, while the starter may be operated by a control device located elsewhere.

DIRECT CURRENT MOTORS

Direct current motors are classified (see Table 1) according to type of winding as: *shunt wound*, *compound wound*, and *series wound*.

Shunt Wound motors, being suitable for application to fans, centrifugal pumps, or similar equipment where the amount of starting torque required is relatively small, are used for the majority of direct current applications in the field of heating, ventilating, and air conditioning. They may be used on reciprocating pumps and compressors if started under unloaded conditions.

Without auxiliary control the shunt wound motor is designated as *constant speed*.* Fig. 1 illustrates the characteristics of direct current motors, showing speed, horsepower, and torque as a function of current. The speed regulation* of small size shunt wound motors from ¾ hp to 5 hp is 12 per cent as specified by the *NEMA* while on larger motors it is 10 per cent.

Compound Wound motors are required for application to reciprocating compressors, stokers, reciprocating pumps when started under loaded

*Refer to Glossary at end of chapter.

conditions, and other similar equipment requiring high starting torque. The characteristics of this type of motor are such that for starting torques above full-load torque the starting current required is somewhat less than for the shunt wound motor. Compound wound direct current motors are normally used whenever frequent starting makes high starting and accelerating torque desirable. Without auxiliary control, compound wound motors are designated as *varying speed*,* and have a speed regulation of 25 per cent.

Series Wound motors find only limited application in a few special cases and are available in a limited range of sizes. The motors are used where extremely high starting torques are required and must be applied only to direct coupled continuous loads due to the fact that the speed

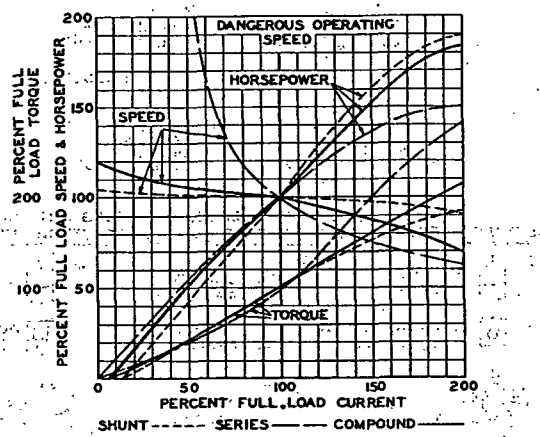

FIG. 1. CHARACTERISTICS OF DIRECT CURRENT MOTORS

of the motor becomes dangerously high when the motor is operated at a light load.

Typical d-c motor specifications are shown on page 613.

DIRECT CURRENT MOTOR CONTROL

Direct current motors are usually started through starting controllers which use a resistance, in series with the motor armature, which is gradually cut out as the motor comes up to speed. Motors up to 2 hp may be linestarted providing the inrush current causes no serious voltage fluctuations in the power supply line.

Constant Speed and Varying Speed Motors. As shown in Fig. 2, the recommended practice for manual starting of motors over ½ hp requires the use of a fused safety switch or circuit breaker and a face-plate type starter. For automatic push button starting a safety switch or circuit breaker and an automatic starter are recommended.

*Refer to Glossary at end of chapter.