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

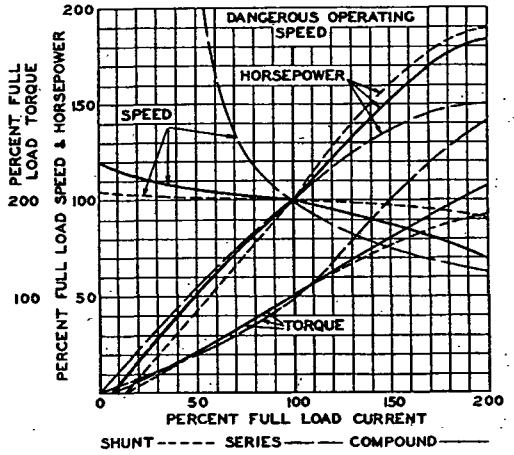


FIG. 1. CHARACTERISTICS OF DIRECT CURRENT MOTORS

where extremely high starting torques are required and must be applied only to direct coupled continuous loads due to the fact that the speed of the motor becomes dangerously high when the motor is operated at a light load.

Typical d-c motor specifications are shown on page 634.

DIRECT CURRENT MOTOR CONTROL

Direct current motors are always 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 of small ratings may be linestarted providing the inrush current causes no serious voltage fluctuations in the power supply line.

Constant Speed and *Varying Speed* motors in ratings up to 2 hp may be linestarted. As shown in Fig. 2, the recommended practice for manual starting of motors over ½ hp requires the use of a disconnecting switch

*Refer to Glossary at end of chapter.

and a face-plate type starter. For automatic push button starting a disconnecting switch and an automatic starter are recommended.

Adjustable Speed motors are normally shunt wound and are operated at various speeds by varying a resistance connected in series with the motor field. A maximum range of speed of about 5 to 1 can be obtained by this means. Rated speed regulation is 22 per cent for motors of this type from 2 to 5 hp; 15 per cent is standard in larger sizes. The *NEMA* practice on rating adjustable speed d-c motors is defined in the Glossary at the end of the chapter.

The control for the adjustable speed motor consists of the addition of

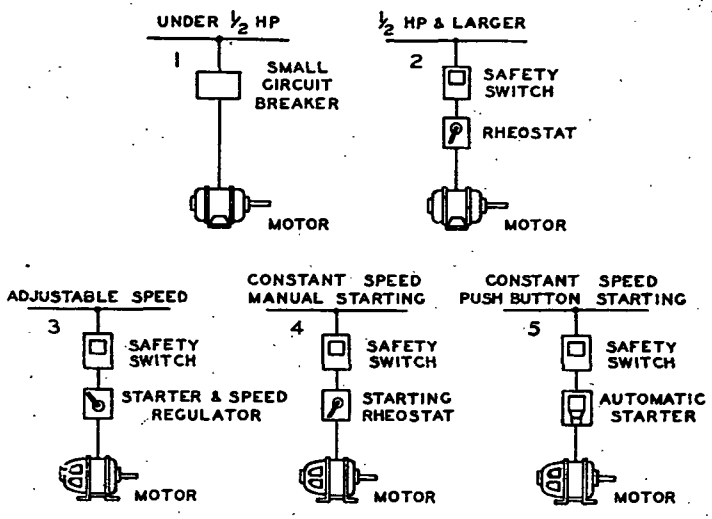


FIG. 2. RECOMMENDED CONTROLS FOR D-C MOTORS

a field rheostat for speed control to the equipment specified for the constant speed motor.

*Adjustable Varying Speed** motors are d-c motors in which the speed is varied by the addition of resistance in series with the armature. The speed of the motor by this means is always less than the rated full field speed and varies widely with a change in load, especially with high series resistance. Fig. 3 illustrates typical speed characteristics of this type of motor for different values of armature resistance.

The addition of series resistance in the armature circuit reduces the motor speed by lowering the voltage on the armature. At one-half speed the voltage is approximately one-half of line voltage. Consequently, with rated full load current the power delivered by the motor will be only one-half of the maximum, *e.g.*, it will be 5 hp from a 10 hp motor, because the other 5 hp will be lost in the resistance. It is, therefore, evident that the efficiency of the motor is reduced at reduced speeds due to the loss in the resistor.

Control for the adjustable varying speed motor is similar to that for

*Refer to Glossary at end of chapter.