FIGURE 9.1 A typical solenoid-operated starter.

FIGURE 9.2 Some column-mounted ignition switches act directly on the electrical ignition switch itself, whereas others use a link from the lock cylinder to the ignition switch.

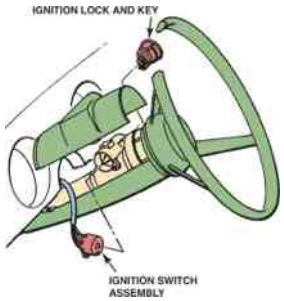


FIGURE 9.3 To prevent the engine from cranking, an electrical switch is usually installed to open the circuit between the ignition switch and the starter solenoid.

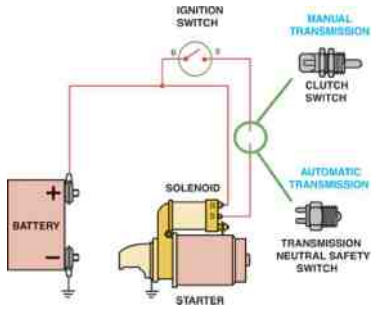


FIGURE 9.4 Instead of using an ignition key to start the engine, some vehicles are using a start button which is also used to stop the engine, as shown on this Jaguar.

FIGURE 9.5 The top button on this key fob is the remote start button.

NOTE: Most remote start systems will turn off the engine after 10 minutes of run time unless reset by using the remote.

FIGURE 9.6 This series-wound electric motor shows the basic operation with only two brushes: one hot brush and one ground brush. The current flows through both field coils, then through the hot brush and the loop winding of the armature, before reaching ground through the ground brush.

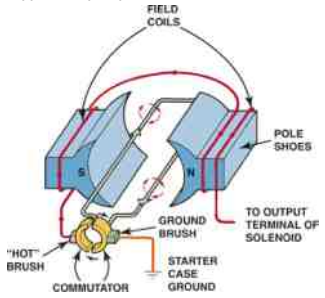


FIGURE 9.7 The interaction of the magnetic fields of the armature loops and field coils creates a stronger magnetic field on the right side of the conductor, causing the armature loop to move toward the left.

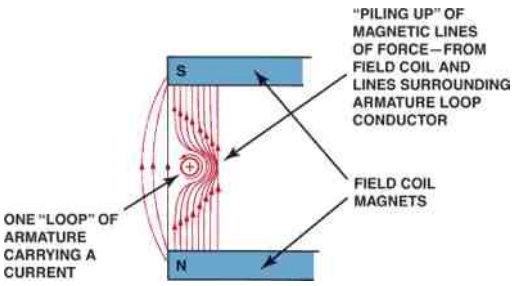


FIGURE 9.8 The armature loops rotate due to the difference in the strength of the magnetic field. The loops move from a strong magnetic field strength toward a weaker magnetic field strength.

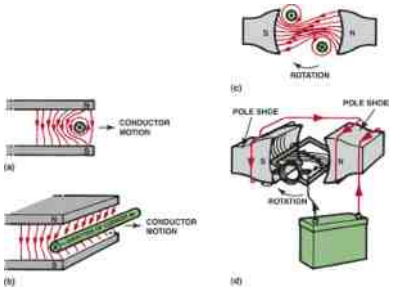


FIGURE 9.9 Magnetic lines of force in a four-pole motor.

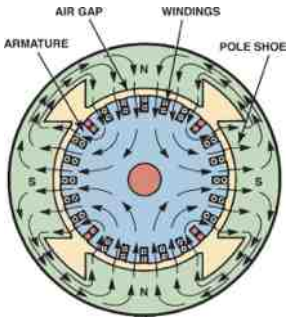


FIGURE 9.10 A pole shoe and field winding.

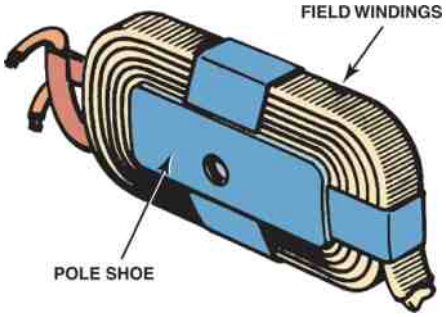


FIGURE 9.11 This wiring diagram illustrates the construction of a series-wound electric motor. Notice that all current flows through the field coils, then through the armature (in series) before reaching ground.

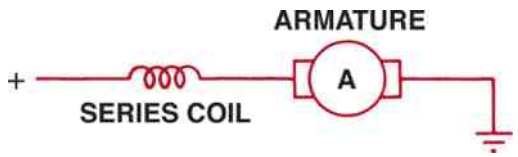


FIGURE 9.12 This wiring diagram illustrates the construction of a shunt-type electric motor, and shows the field coils in parallel (or shunt) across the armature.

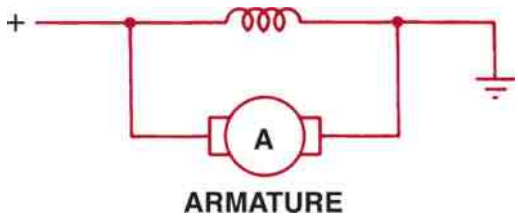


FIGURE 9.13 A compound motor is a combination of series and shunt types, using part of the field coils connected electrically in series with the armature and some in parallel (shunt).

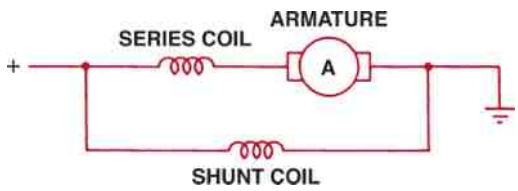


FIGURE 9.14 A typical starter motor showing the drive-end housing.

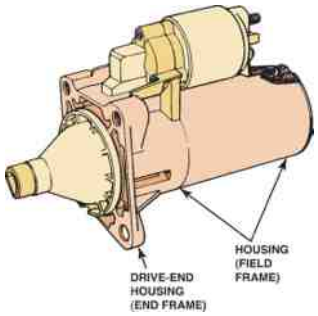


FIGURE 9.15 Pole shoes and field windings installed in the housing.

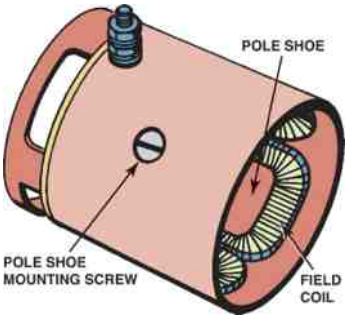


FIGURE 9.16 A typical starter motor armature. The armature core is made from thin sheet metal sections assembled on the armature shaft, which is used to increase the magnetic field strength.

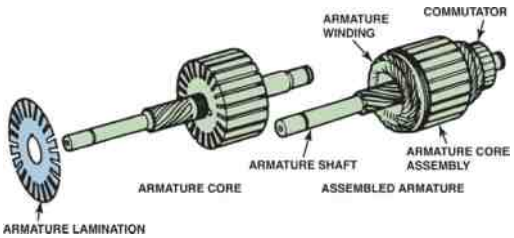


FIGURE 9.17 An armature showing how its copper wire loops are connected to the commutator.

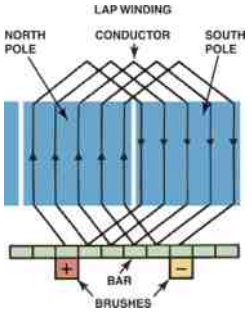
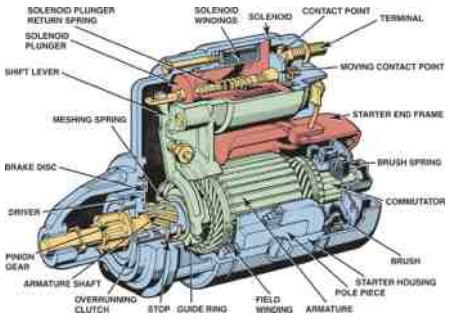


FIGURE 9.18 A cutaway of a typical starter motor showing the commutator, brushes, and brush spring.



TECH TIP

Don't Hit That Starter!

In the past, it was common to see service technicians hitting a starter in their effort to diagnose a no-crank condition. Often the shock of the blow to the starter aligned or moved the brushes, armature, and bushings. Many times, the starter functioned after being hit, even if only for a short time.

However, most starters today use permanent magnet fields, and the magnets can be easily broken if hit. A magnet that is broken becomes two weaker magnets. Some early PM starters used magnets that were glued or bonded to the field housing. If struck with a heavy tool, the magnets could be broken with parts of the magnet falling onto the armature and into the bearing pockets, making the starter impossible to repair or rebuild. **SEE FIGURE 9–19.**

FIGURE 9.19 This starter permanent magnet field housing was ruined when someone used a hammer on the field housing in an attempt to "fix" a starter that would not work. A total replacement is the only solution in this case.

FIGURE 9.20 A typical gear-reduction starter.

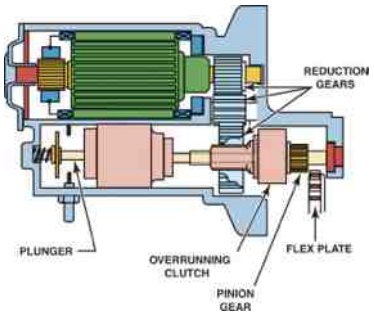


FIGURE 9.21 A cutaway of a typical starter drive showing all of the internal parts.

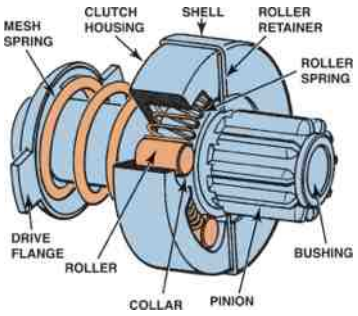


FIGURE 9.22 The ring gear to pinion gear ratio is usually 15:1 to 20:1.

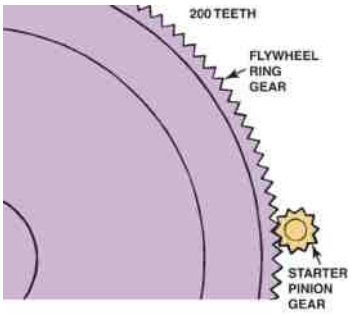
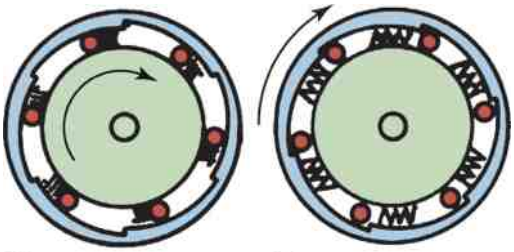


FIGURE 9.23 Operation of the overrunning clutch. (a) Starter motor is driving the starter pinion and cranking the engine. The rollers are wedged against spring force into their slots. (b) The engine has started and is rotating faster than the starter armature. Spring force pushes the rollers so they can rotate freely.



FREQUENTLY ASKED QUESTION

What Is a Bendix?

Older-model starters often used a Bendix drive mechanism, which used inertia to engage the starter pinion with the engine flywheel gear. Inertia is the tendency of a stationary object to remain stationary, because of its weight, unless forced to move. On these older-model starters, the small starter pinion gear was attached to a shaft with threads, and the weight of this gear caused it to be spun along the threaded shaft and mesh with the flywheel whenever the starter motor spun. If the engine speed was greater than the starter speed, the pinion gear was forced back along the threaded shaft and out of mesh with the flywheel gear. The Bendix drive mechanism has generally not been used since the early 1960s, but some technicians use this term when describing a starter drive.

FIGURE 9.24 A Ford movable pole shoe starter.

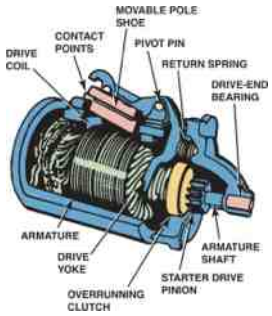
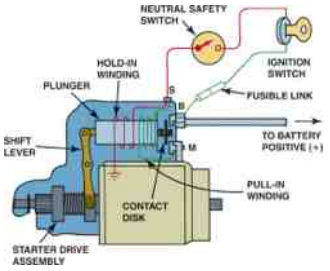


FIGURE 9.25 Wiring diagram of a typical starter solenoid. Notice that both the pull-in winding and the hold-in winding are energized when the ignition switch is first turned to the "start" position. As soon as the solenoid contact disk makes electrical contact with both the B and M terminals, the battery current is conducted to the starter motor and electrically neutralizes the pull-in winding.



FREQUENTLY ASKED QUESTION

How Are Starters Made So Small?

Starters and most components in a vehicle are being made as small and as light in weight as possible to help increase vehicle performance and fuel economy. A starter can be constructed smaller due to the use of gear reduction and permanent magnets to achieve the same cranking torque as a straight drive starter, but using much smaller components. **SEE FIGURE 9–26** for an example of an automotive starter armature that is palm size.

FIGURE 9.26 A palm-size starter armature.