IGNITION SYSTEMS

The ignition system in today's vehicles is an integral part of the electronic engine control system. The engine control module (ECM), or powertrain control module (PCM), controls all functions of the ignition system and constantly corrects the spark timing. The desired ignition timing is calculated by the PCM according to inputs from a variety of sensors. These inputs allow the PCM to know the current operating conditions.

The PCM matches those conditions to its programming and controls ignition timing accordingly. It is important to remember that there has always been a need for engine speed- and load-based timing adjustments. Electronic systems are very efficient at making these adjustments. Many of the inputs used for ignition system control are also used to control other systems, such as fuel injection. These inputs are available on the CAN buses **(Figure 26–1)** .

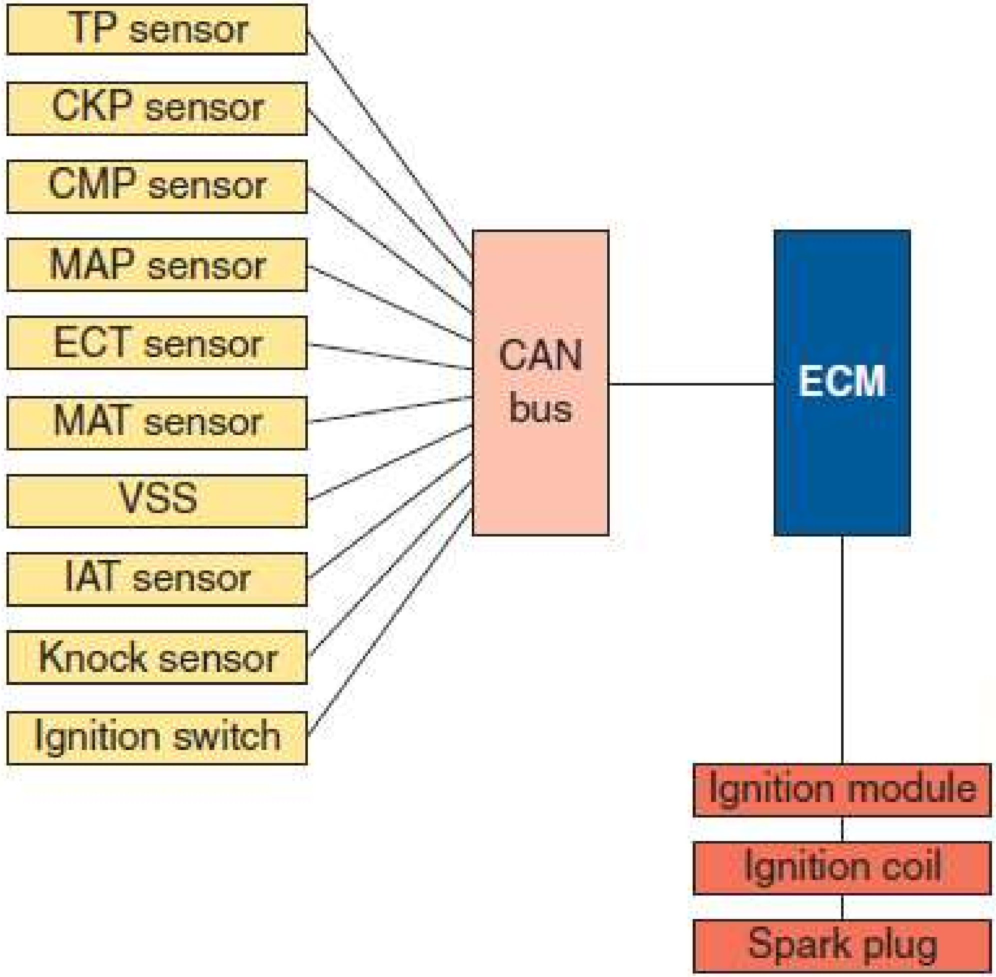

Figure 26-1 Many of the inputs used for ignition system control are also used to control other systems and are available on the CAN buses.

BASIC CIRCUITRY

All ignition systems consist of two interconnected electrical circuits: a primary (low-voltage) circuit and a secondary (high-voltage) circuit (Figure 26–2) . Depending on the exact type of ignition system, components in the primary circuit include the following:

■ Battery

■ Ignition switch

■ Ballast resistor or resistance wire (some old systems)

■ Starting bypass (some old systems)

■ Ignition coil primary winding

■ Triggering device

■ Switching device or control module (igniter)

The secondary circuit includes these components:

■ Ignition coil secondary winding

■ Distributor cap and rotor (some systems)

■ High-voltage cables (some systems)

■ Spark plugs

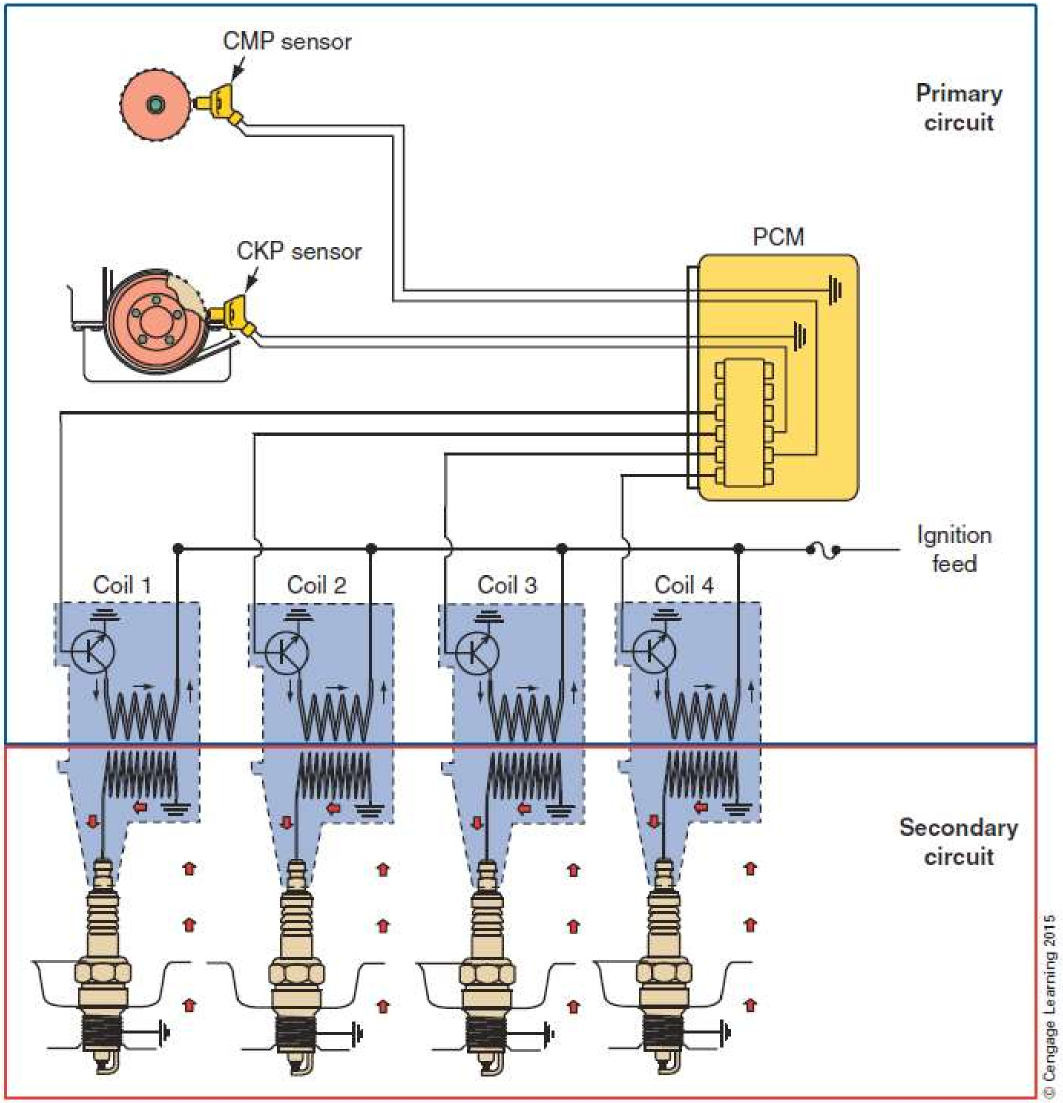

Figure 26-2 Ignition systems have a primary (low-voltage) and a secondary (high-voltage) circuit.

Primary Circuit Operation

When the ignition switch is on, voltage from the battery is supplied to the positive connection of the primary through the ignition switch, ignition control module, or PCM depending on the system.

The negative connection of the primary winding is connected to a switching device. This can be an ignition control module or the PCM. When the switch is closed, current flows through the circuit. The current flow through the ignition coil's primary winding creates a magnetic field. As the current continues to flow, the magnetic field gets stronger.

When the triggering device signals to the switching unit that the piston is approaching TDC on the compression stroke, the circuit opens and current flow is stopped. This causes the magnetic field around the primary winding to collapse across the secondary winding.

The movement of the magnetic field across the winding induces a high voltage in the secondary winding. The action of the secondary circuit begins at this point.

Secondary Circuit Operation

The secondary circuit carries high voltage to the spark plugs. The exact manner in which the secondary circuit delivers these high-voltage surges depends on the system.

Until 1984 all ignition systems used some type of distributor to accomplish this job. However, in an effort to reduce emissions, improve fuel economy, and boost component reliability, auto manufacturers are now using distributorless or electronic ignition (EI) systems.

DI Systems In a distributor ignition system, the high voltage from the secondary winding is delivered to the distributor by an ignition cable or through an internal connection in the distributor cap. The distributor then distributes the high voltage to the individual spark plugs through a set of ignition cables **(Figure 26–3)** . The cables are arranged in the distributor cap according to the firing order of the engine. A rotor driven by the distributor shaft rotates and completes the electrical path from the secondary winding of the coil to the individual spark plugs.

The distributor delivers the spark to match the compression stroke of the piston. The distributor assembly may also have the capability of advancing or retarding ignition timing.

The distributor cap is mounted on top of the distributor assembly and an alignment notch in the cap fits over a matching lug on the housing. Therefore, the cap can only be installed in one position, which ensures the correct firing sequence.

The rotor is positioned on top of the distributor shaft, and a projection inside the rotor fits into a slot in the shaft. This allows the rotor to be installed in only one position.

A metal strip on the top of the rotor makes contact with the center distributor cap terminal, and the outer end of the strip rotates past the cap terminals **(Figure 26–4)**. This action completes the circuit between the ignition coil and the individual spark plugs according to the firing order.

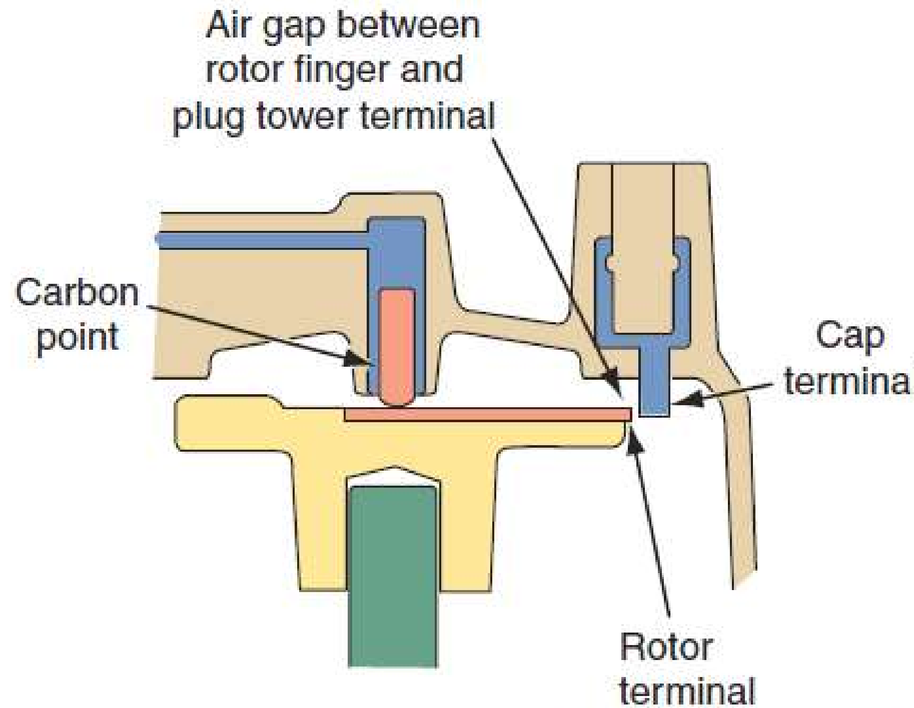

Figure 26-4 The relationship of a rotor and distributor cap.

Electronic Injection Systems

EI systems have no distributor; spark distribution is controlled by an electronic control unit and/or the vehicle's computer **(Figure 26–5)** . Instead of a single ignition coil for all cylinders, each cylinder may have its own ignition coil, or two cylinders may share one coil. The coils are wired directly to the spark plug they control. An ignition control module, tied into the vehicle's computer control system, controls the firing order and the spark timing and advance. The energy produced by the secondary winding is voltage. This voltage is used to establish a complete circuit so current can flow. The excess energy is used to maintain the current flow across the spark plug's gap. Distributorless ignition systems **Figure 26–3 A typical distributor.** are capable of producing much higher energy than conventional ignition systems. This is because having multiple coils allows for increased current flow and coil charge time.

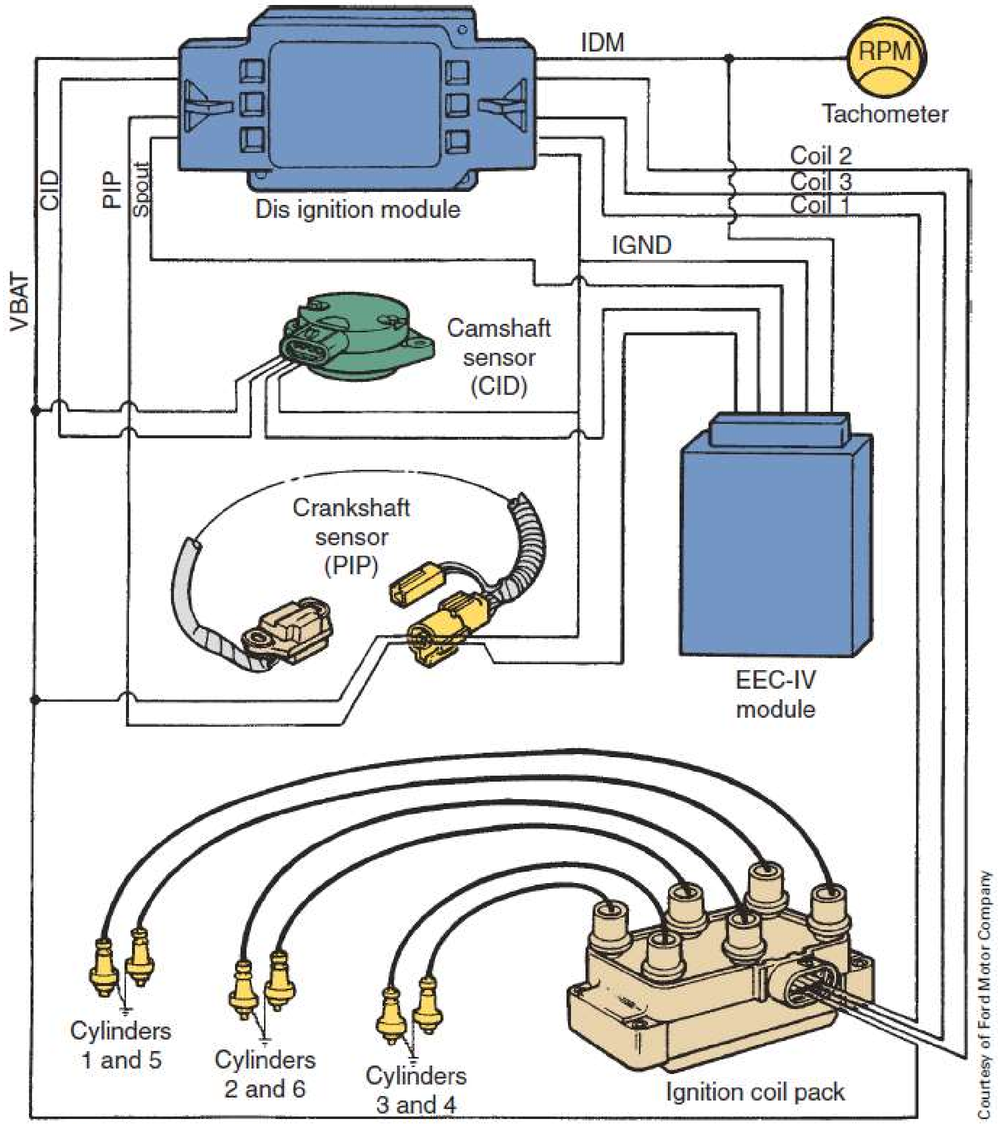

Figure 26-5 An electronic ignition system for a six-cylinder engine.

IGNITION COMPONENTS

All ignition systems share a number of common components. Some, such as the battery and ignition switch, perform simple functions. The battery supplies low voltage current to the ignition primary circuit. The current flows when the ignition switch is in the start or run position. Full-battery voltage is always present at the ignition switch, as if it were directly connected to the battery.

Ignition Coils

To generate a spark to begin combustion, the ignition system must deliver high voltage to the spark plugs. Because the amount of voltage required to bridge the gap of the spark plug varies with the operating conditions, most late model vehicles can easily supply 30,000 to 60,000 volts or more to force a spark across the air gap. Since the battery delivers 12 volts , a method of stepping up the voltage must be used.

Multiplying battery voltage is the job of a coil. The ignition coil is a pulse transformer that transforms battery voltage into short bursts of high voltage. The trade-off is that the large amount of current flow in the primary circuit is proportionally decreased in the secondary. The result is the low voltage high current of the primary is changed into a high voltage, low amperage spark from the secondary.

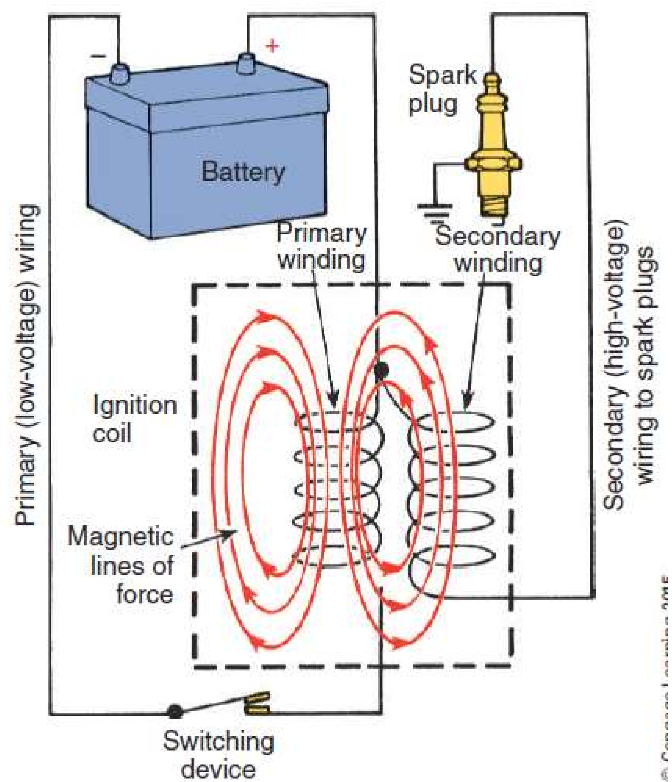

Figure 26-6 Current passing through the coil's primary winding creates magnetic lines of force that cut across and induce voltage in the secondary windings.

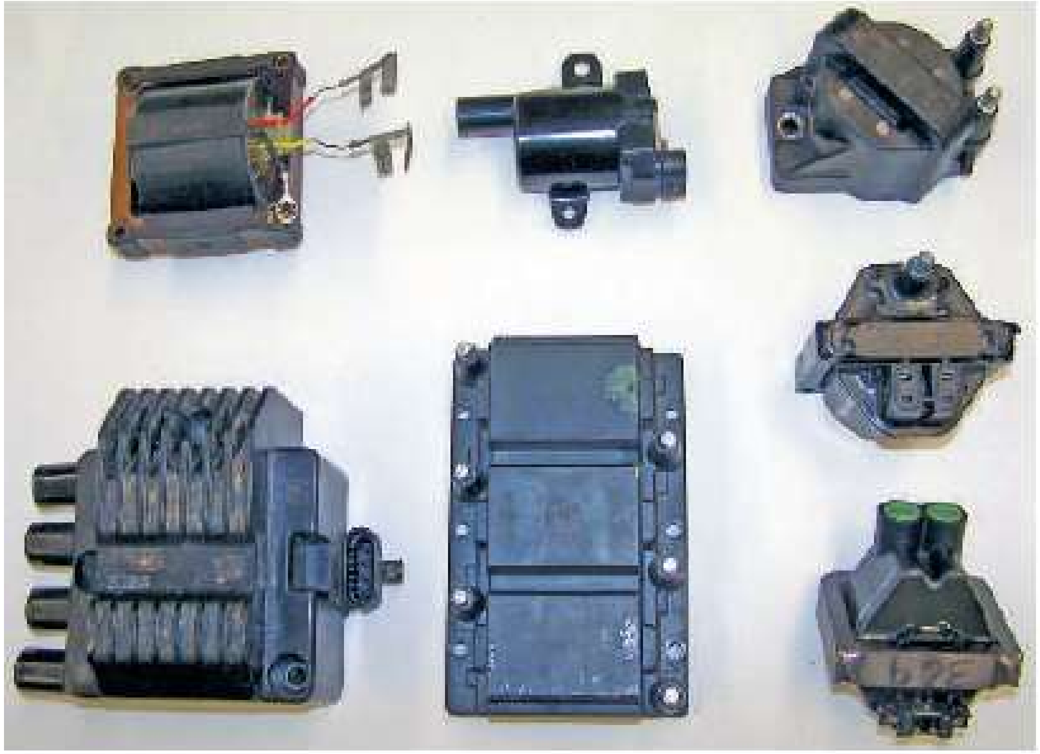

Figure 26-8 Many different ignition coil designs can be found on today's vehicles.

SPARK PLUGS

Spark plugs provide the crucial **air gap** across which the high voltage from the coil causes an arc or spark. The main parts of a spark plug are a steel shell; a ceramic core or insulator, which acts as a heat conductor; and a pair of electrodes, one insulated in the core and the other grounded on the shell.

The shell holds the ceramic core and electrodes in a gas-tight assembly and has threads for plug installation in the engine **(Figure 26–9)** . The insulator material may be alumina silicate or a black-glazed, zirconia-enhanced ceramic insulator to provide for increased durability and strength. The shell may be coated with corrosion resistance material and/or materials that prevent the threads from seizing to the cylinder head.

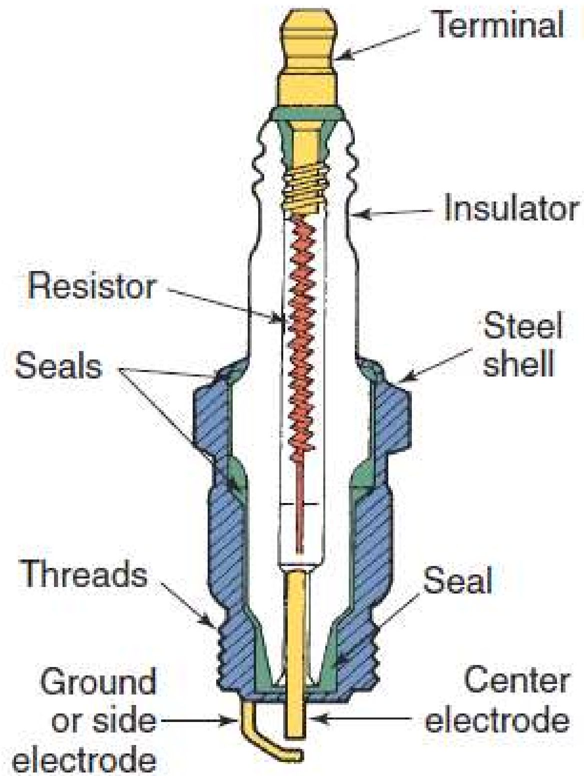

Figure 26-9 Components of a typical spark plug.

Ignition Cables

Spark plug cables, or ignition cables, make up the secondary wiring. These cables carry the high voltage from the distributor or the multiple coils to the spark plugs. The cables are not solid wire; instead they contain carbon fiber cores that act as resistors in the secondary circuit **(Figure 26–15)** .

They cut down on radio and television interference, increase firing voltages, and reduce spark plug wear by decreasing current. Insulated boots on the ends of the cables strengthen the connections as well as prevent dust and water infiltration and voltage loss.

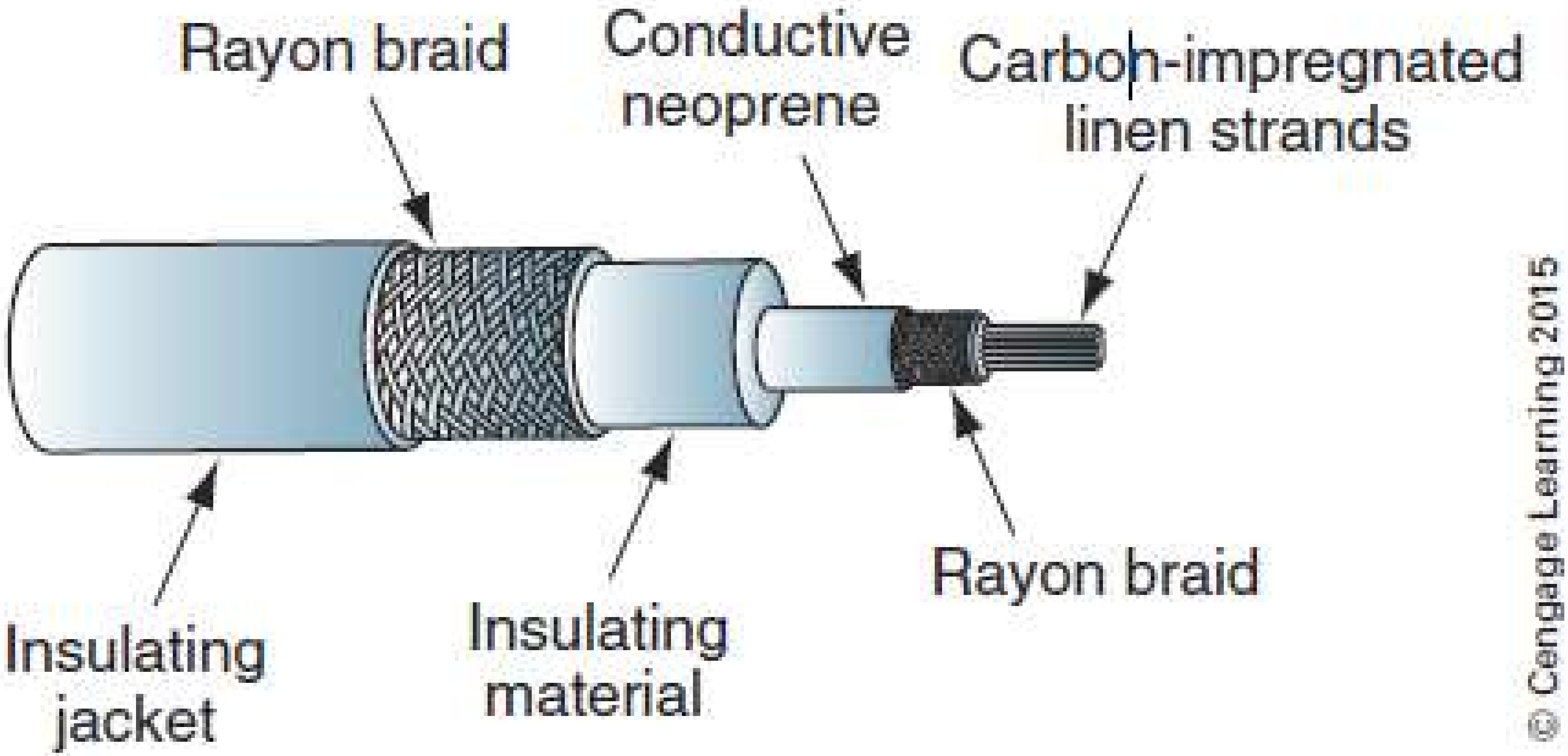

Figure 26-15 Spark plug cable construction.

TRIGGERING AND SWITCHING DEVICES

Triggering and switching devices are used to ensure the spark occurs at the correct time. A triggering device is simply a device that monitors the movement of the engine’s crankshaft and pistons. A switching device is what controls current flow through the primary winding.

When the triggering device sends a signal to the switching device that the piston of a particular cylinder is on the compression stroke, the switching device stops current flow to the primary winding.

This interruption of current flow happens when the PCM decides it is best to fire the spark plug. Electronic switching components are normally located in an ignition control module, which may be part of the vehicle’s PCM. On older vehicles, the ignition module may be built into the distributor or mounted in the engine compartment.

ENGINE POSITION SENSORS

The time when the primary circuit must be opened and closed is related to the position of the pistons and the crankshaft. Therefore, the position of the crankshaft is used to control the flow of current to the base of the switching

transistor.

A number of different types of sensors are used to monitor the position of the crankshaft and control the flow of current to the base of the transistor. These engine position sensors and generators serve as triggering devices and include magnetic pulse generators, metal detection sensors, Hall-effect sensors, magnetoresistive sensors, and photoelectric (optical) sensors.

DISTRIBUTOR IGNITION SYSTEM OPERATION

The primary circuit of a DI system is controlled by a triggering device and a switching device located inside the distributor or external to it. Although these systems are no longer used by auto makers, there are many of them still on the road and they need service.

Distributor

The reluctor, or trigger wheel, and distributor shaft assembly rotate on bushings in the aluminum distributor housing. A roll pin extends through a retainer and the distributor shaft to hold the shaft in place in the distributor. Another roll pin is used to fasten the drive gear to the lower end of the shaft. This drive gear typically meshes with a drive gear on the engine's camshaft. The gear size is designed to drive the distributor shaft at the same speed as the camshaft, which rotates at one-half the speed of the crankshaft.