

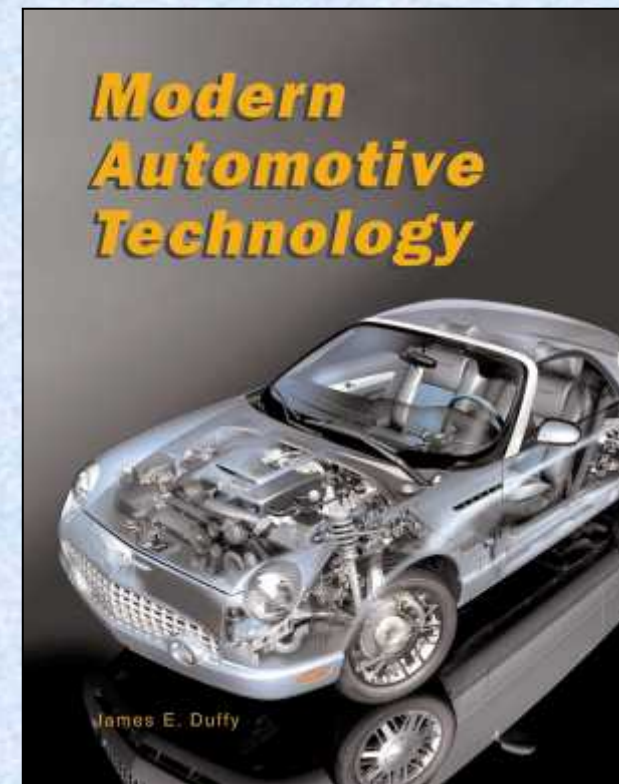
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# Modern Automotive Technology

by  
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# **Chapter 35**

## **Ignition System Fundamentals**



# Contents

(16 Topics)

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- ☐ Basic ignition system
- ☐ Ignition system supply voltage
- ☐ Primary and secondary circuits
- ☐ Ignition coil
- ☐ Ignition distributors
- ☐ Contact point ignition system
- ☐ Electronic ignition system

# Contents

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- ☐ Secondary wires
- ☐ Spark plugs
- ☐ Ignition timing
- ☐ Crankshaft-triggered ignition
- ☐ Distributorless ignition system
- ☐ Direct ignition system
- ☐ Engine firing order



# Functions of an Ignition System

- ☐ Turns a spark ignition engine on and off
- ☐ Operates on battery or alternator voltage
- ☐ Creates a high voltage arc at the spark plug
- ☐ Distributes high voltage to each spark plug in the correct sequence
- ☐ Times the spark

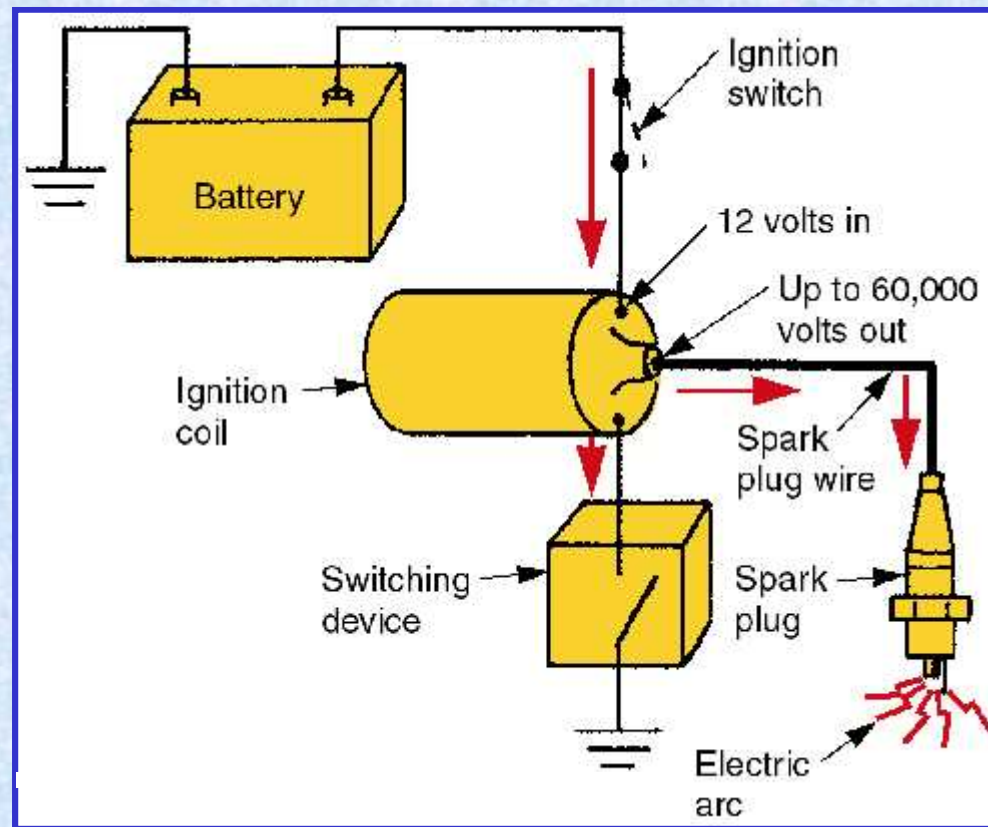
# Basic Ignition System

- ❑ Changes battery voltage to a very high voltage
- ❑ Sends the high voltage to the spark plugs



# Basic Ignition System

Battery voltage is stepped up to about 15,000 volts to fire the spark plug



# Components

- ☐ Battery
- ☐ Ignition switch
- ☐ Ignition coil
- ☐ Switching device
- ☐ Spark plugs
- ☐ Ignition system wires



# Operation

- ❑ With the ignition on and the switching device closed, current flows through the coil
- ❑ When the piston is near TDC on its compression stroke, the switching device opens
- ❑ Current flow through the coil stops, producing a high voltage surge
- ❑ Current arcs across the spark plug gap

# Ignition System Supply Voltage

- ❑ Fed to the ignition system by the battery and alternator
- ❑ Components:
  - ignition switch
  - bypass and resistance circuits



# Ignition Switch

- ❑ Key-operated switch
- ❑ Supplies power to the coil's primary windings
  - directly
  - through bypass and resistance circuits

# Bypass Circuit

- ❑ May be used to supply direct battery voltage to the ignition system during cranking
- ❑ Ensures enough voltage and current for proper ignition coil operation when cranking voltage is low

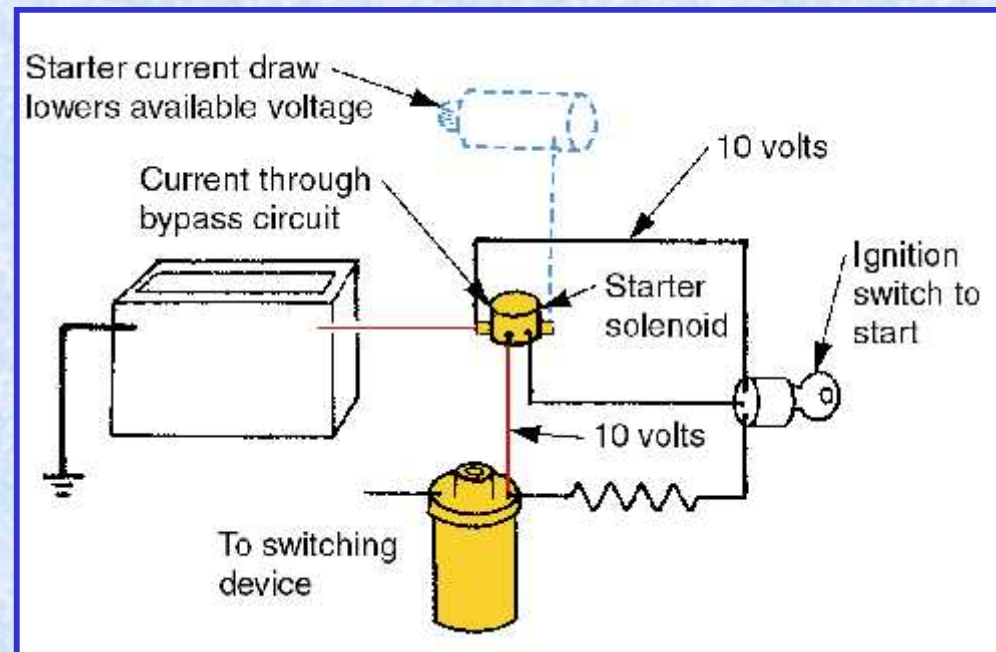


# Resistance Circuit

- ❑ May be used between the ignition switch and coil
- ❑ Limits supply voltage to the ignition system during alternator operation
- ❑ Recent electronic systems do not use bypass or resistance circuits
  - the circuitry inside the ignition control module limits current

# Bypass Circuit

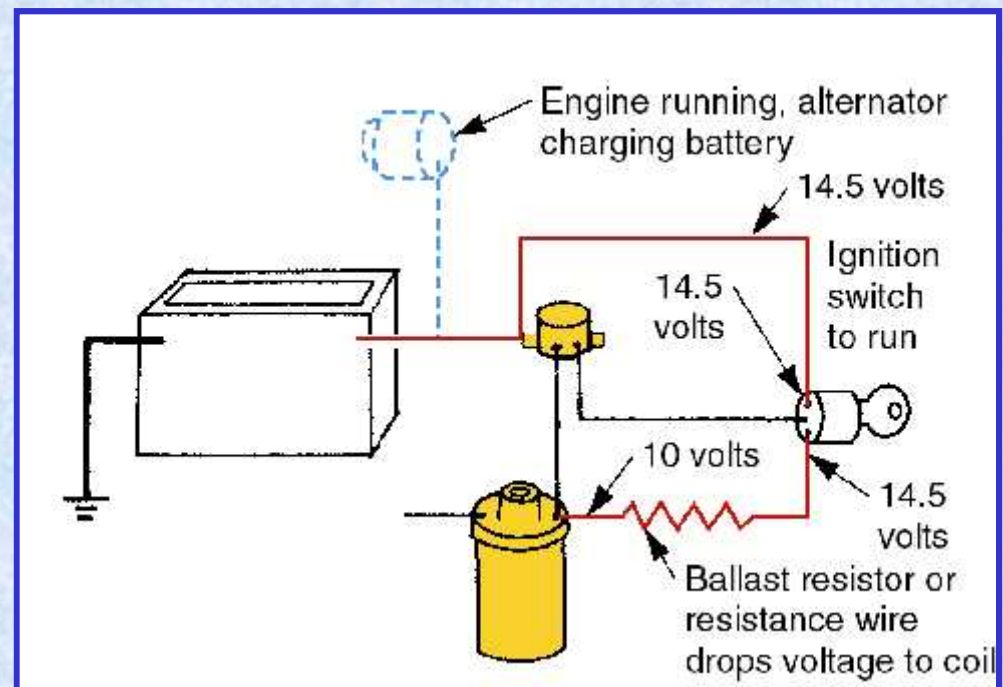
During cranking, the bypass circuit feeds battery voltage to the coil





# Resistance Circuit

After starting, the resistance circuit feeds controlled voltage to the coil



# Primary and Secondary Circuits

- Primary circuit

- operates on low voltage 12–15 volts

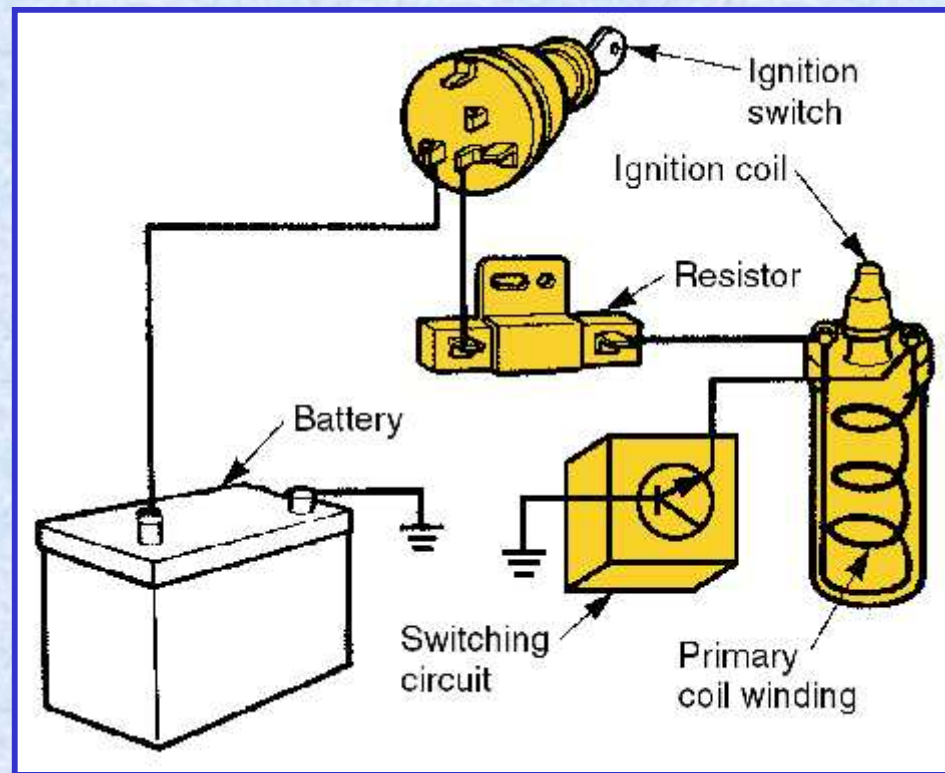
- Secondary circuit

- high voltage section, 4000–30,000 volts
  - includes wires and parts between the coil output and spark plug ground



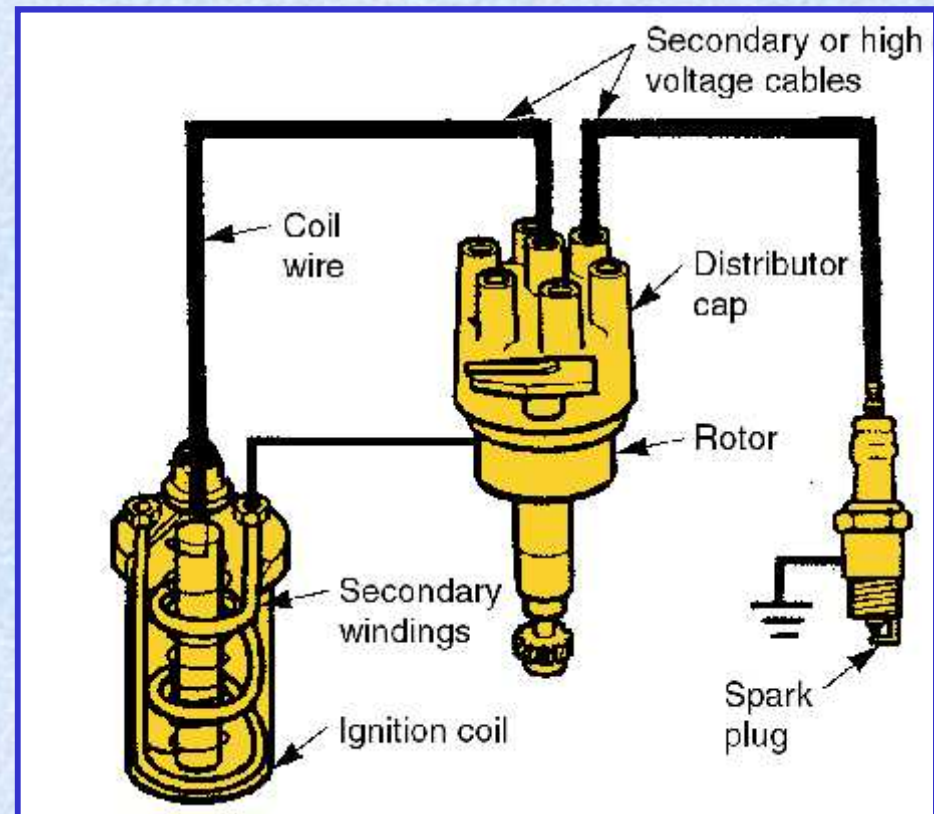
# Primary Circuit

Includes all the parts  
operating at  
battery voltage



# Secondary Circuit

Includes all the parts  
carrying coil  
output voltage





# Ignition Coil

- ❑ Step-up transformer
- ❑ Produces short bursts of high voltage to start combustion
- ❑ The high voltage jumps the rotor gap, passes through the secondary wire, and jumps the spark plug gap
- ❑ 4000-8000 volts on old systems
- ❑ 4000-30,000 volts on newer systems

# Ignition Coil Windings

## □ Primary

- several hundred turns of heavy wire wrapped around or near the secondary windings

## □ Secondary

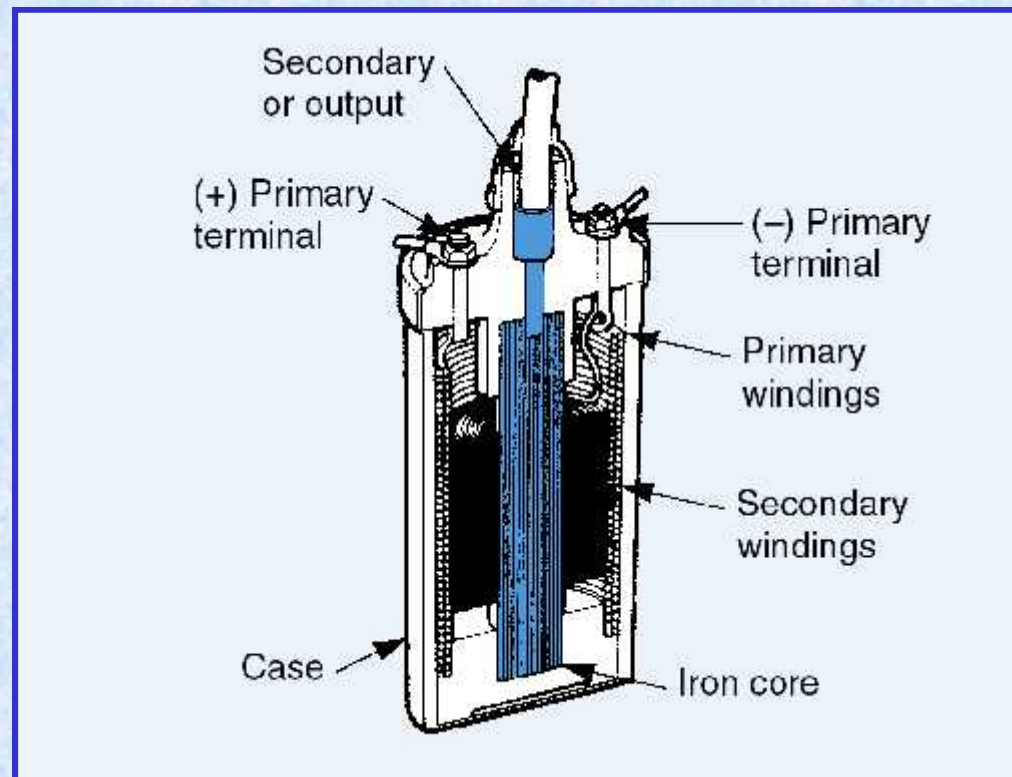
- several thousand turns of fine wire located inside or near primary windings

## □ Iron core

- concentrates the magnetic field

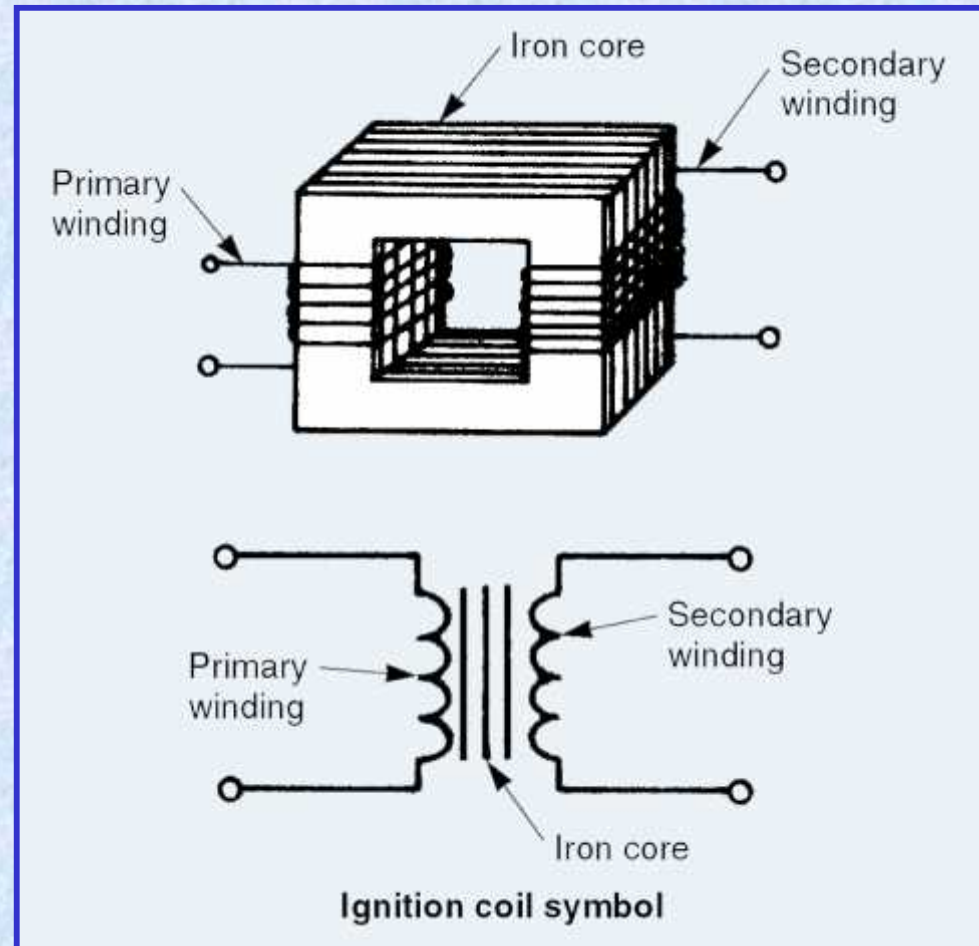


# Ignition Coil



# Ignition Coil

Note how the  
schematic symbol  
relates to its  
construction



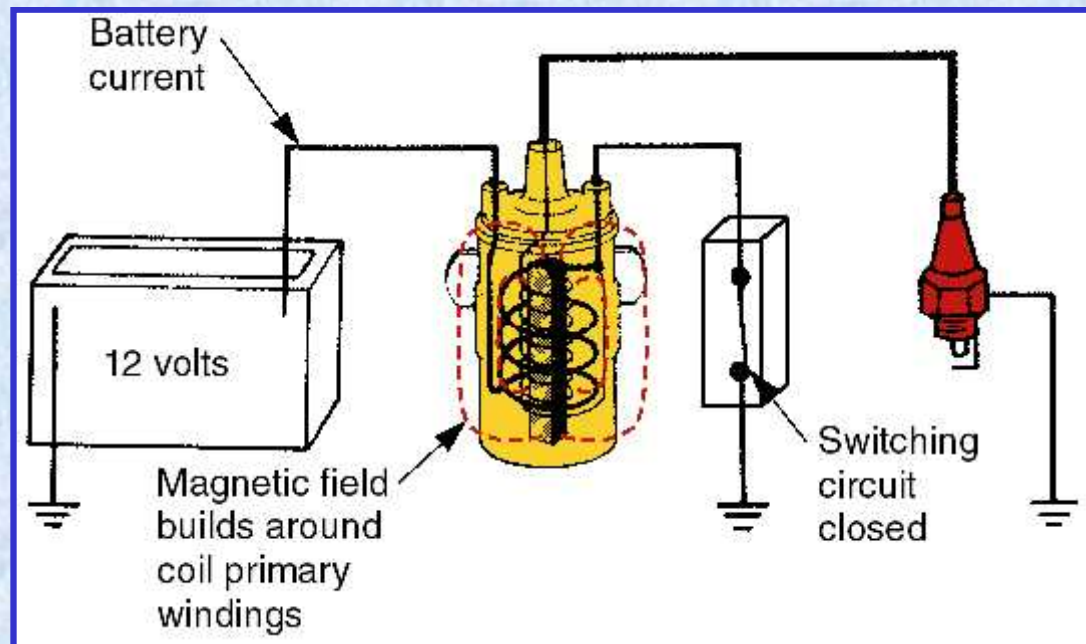


# Coil Operation

- ☐ Current flows through the primary winding
- ☐ A strong magnetic field is generated
- ☐ The iron core helps concentrate the field
- ☐ When the current is interrupted, the magnetic field collapses across the secondary windings
- ☐ Up to 60,000 volts is induced

# Primary Dwell Period

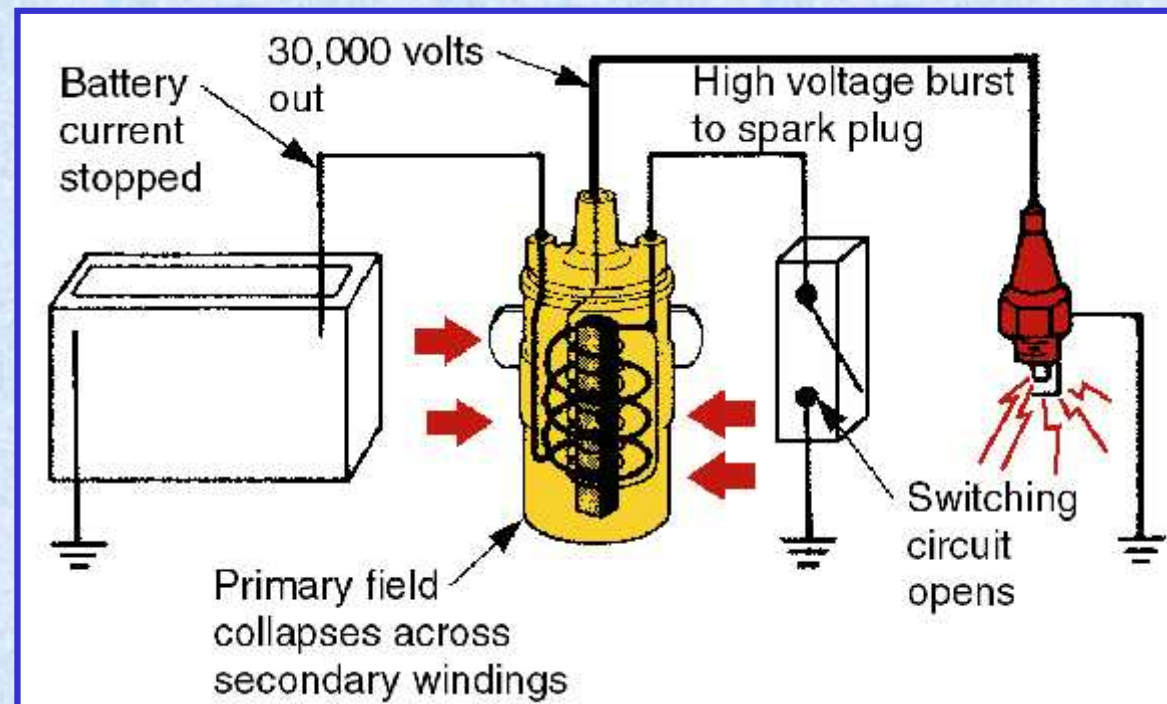
When current flows through the coil primary windings, a magnetic field builds





# Dwell Ending—Ignition

When the current flow stops, the magnetic field collapses across the secondary windings



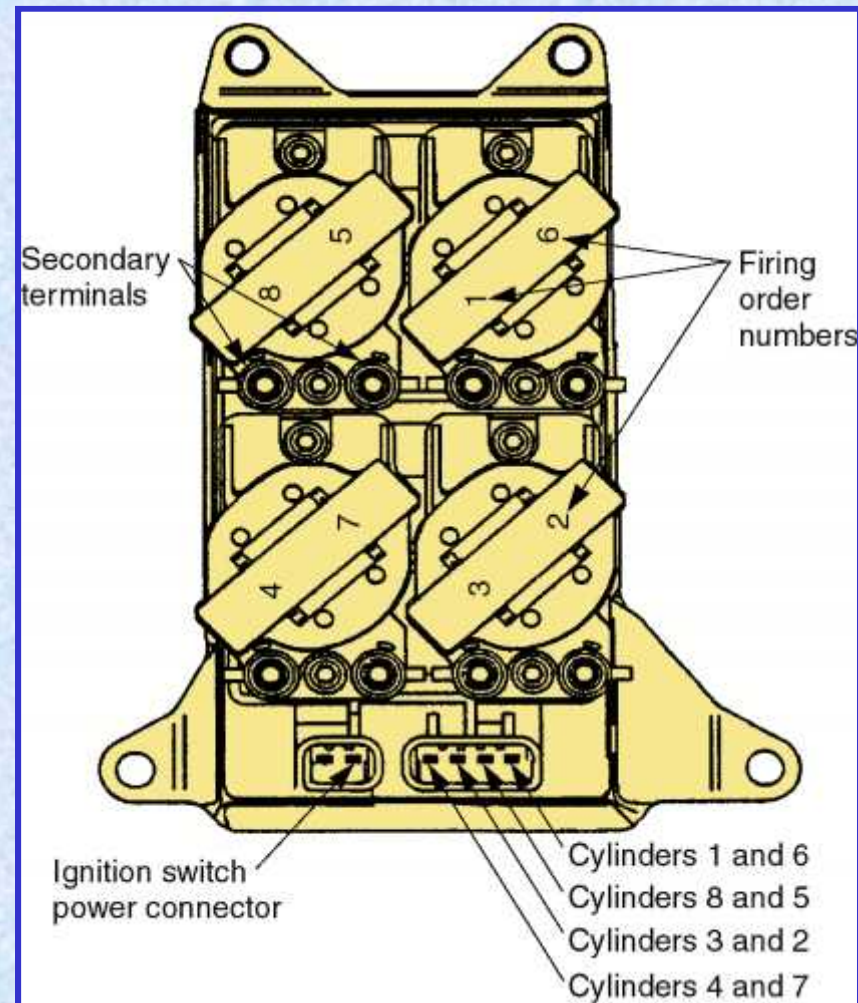
# Ignition Coil Designs

- ❑ Conventional system
  - one coil for all cylinders
- ❑ Distributorless system
  - one coil for every two cylinders
- ❑ Direct ignition system
  - one coil for each cylinder



# Coil Pack

Several coils in one assembly



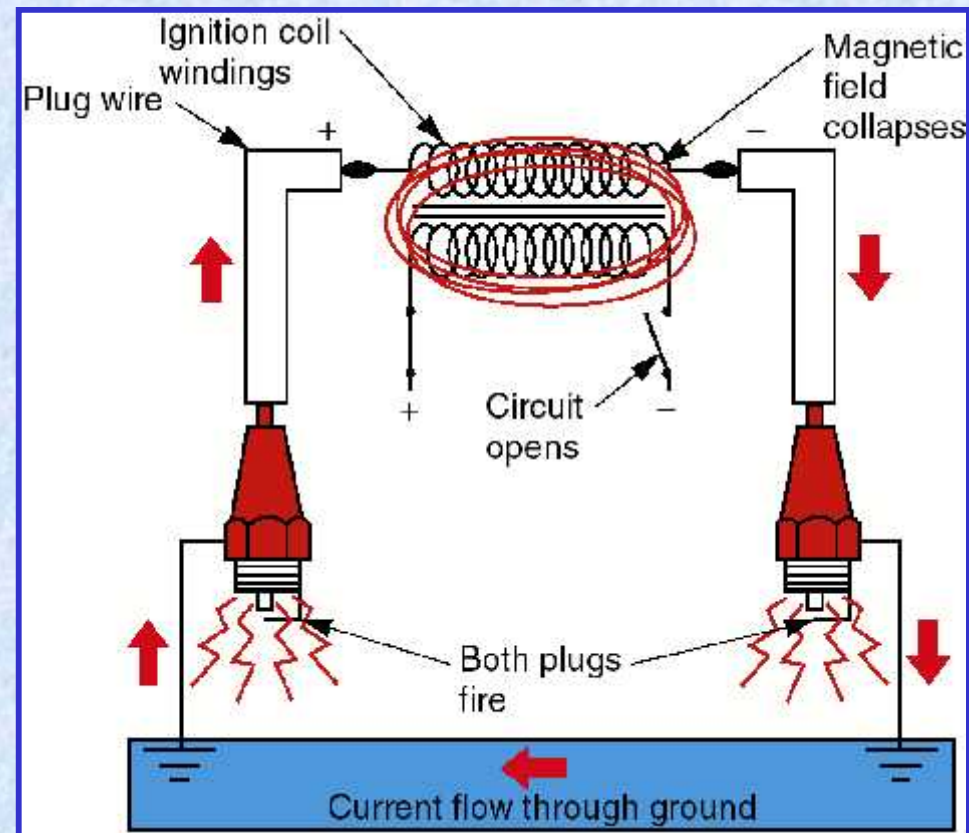
# Wasted-Spark Ignition Coil

- ❑ Fires two spark plugs at the same time
- ❑ Each end of the coil's secondary winding is connected to a spark plug wire
- ❑ High voltage forces current through the two spark plug wires, firing each plug with opposite polarity
- ❑ The engine ground connects the two spark plugs



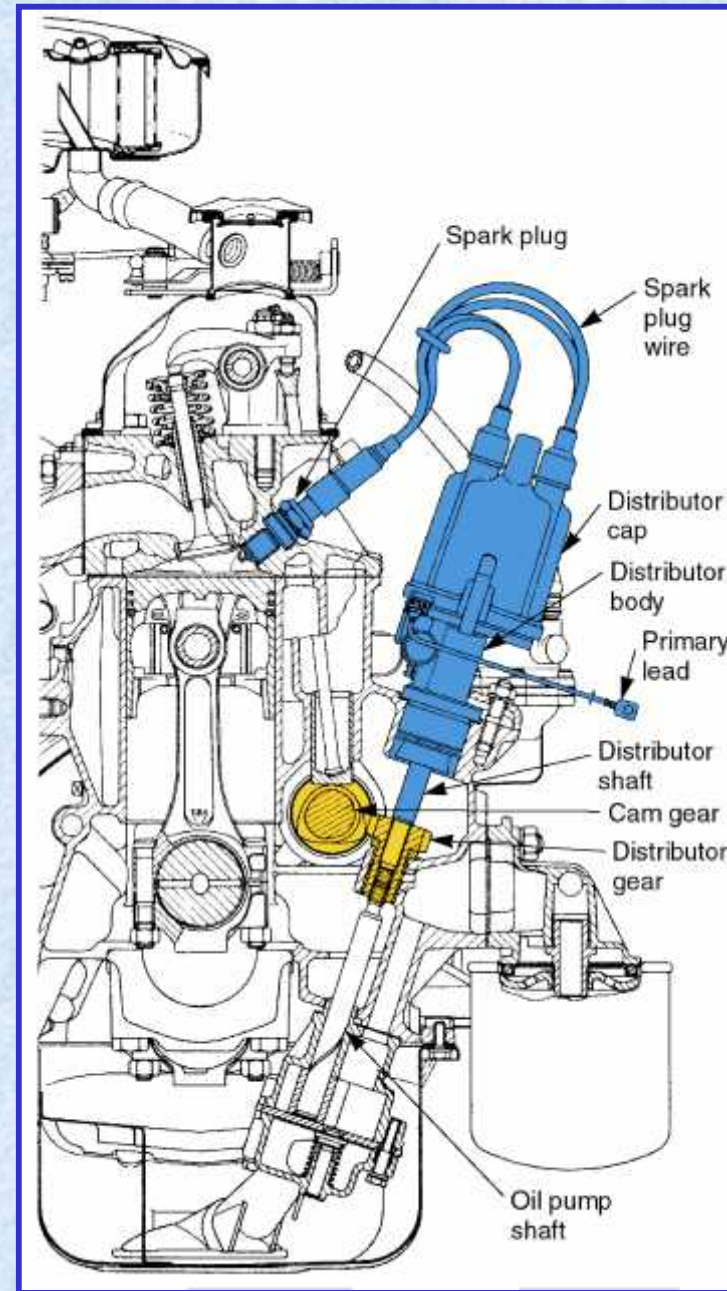
# Wasted-Spark Ignition Coil

One plug fires on compression, the other on the exhaust stroke



# Ignition Distributors

A small gear on the cam drives the distributor at one-half engine speed





# Distributor Functions

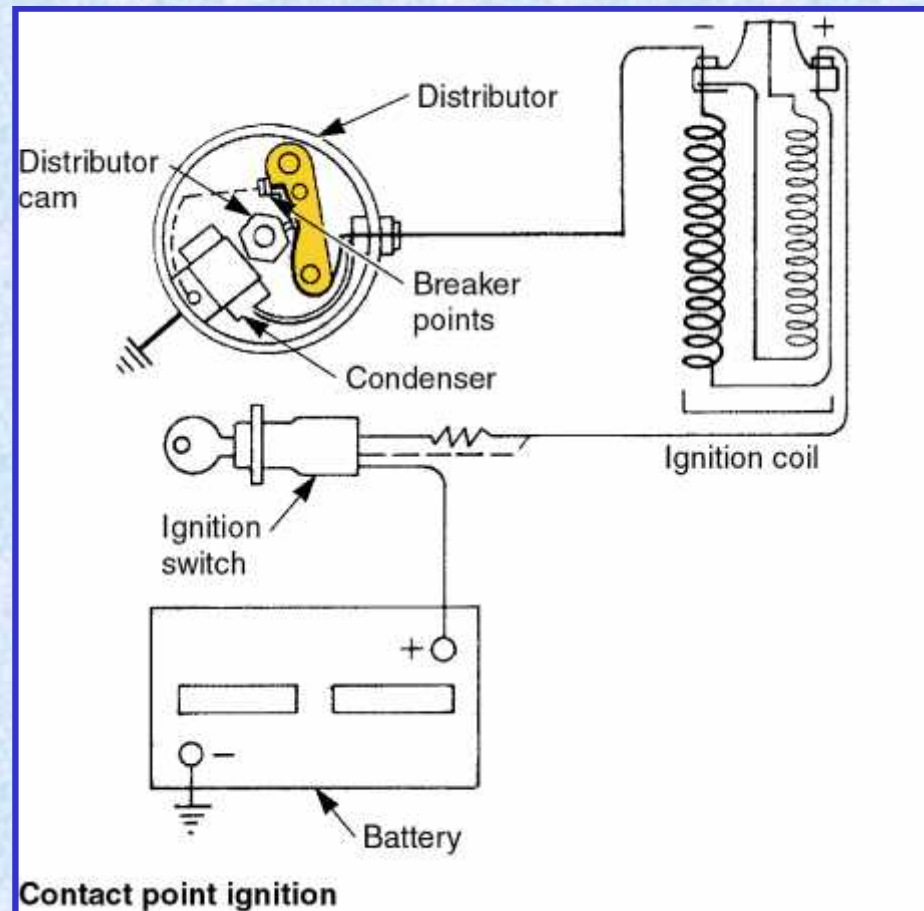
- ☐ Controls the on/off cycles of the coil's primary windings
- ☐ Distributes high-voltage to the spark plugs
- ☐ Controls the timing in relation to speed and load
- ☐ May drive the oil pump
- ☐ May house the ignition coil and the electronic switching circuit

# Distributor Types

- ❑ Contact point
  - older, mechanical type
- ❑ Pickup coil
  - magnetic-sensing coil or winding type
- ❑ Hall-effect
  - magnetic-sensing, solid-state chip type
- ❑ Optical
  - LED and light-sensing type



# Contact Point Ignition System



# Components

- ❑ Distributor cam
  - opens contact points
- ❑ Contact points
  - switches the coil primary ground
- ❑ Condenser
  - prevents the contact points from arcing and burning

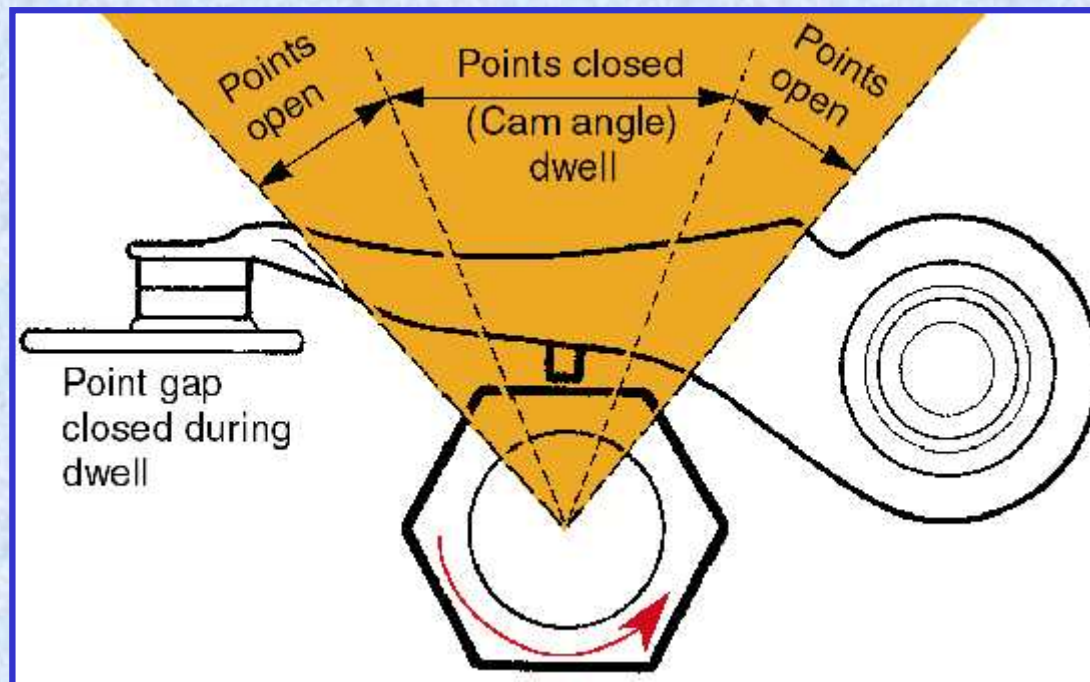


# Operation

- ❑ When the distributor rotates, the cam opens the contact points once for each cylinder
- ❑ Spring force closes the contact points
- ❑ When the points are closed, the coil's magnetic field builds
- ❑ When the points open, the field collapses and high voltage is sent to the spark plug

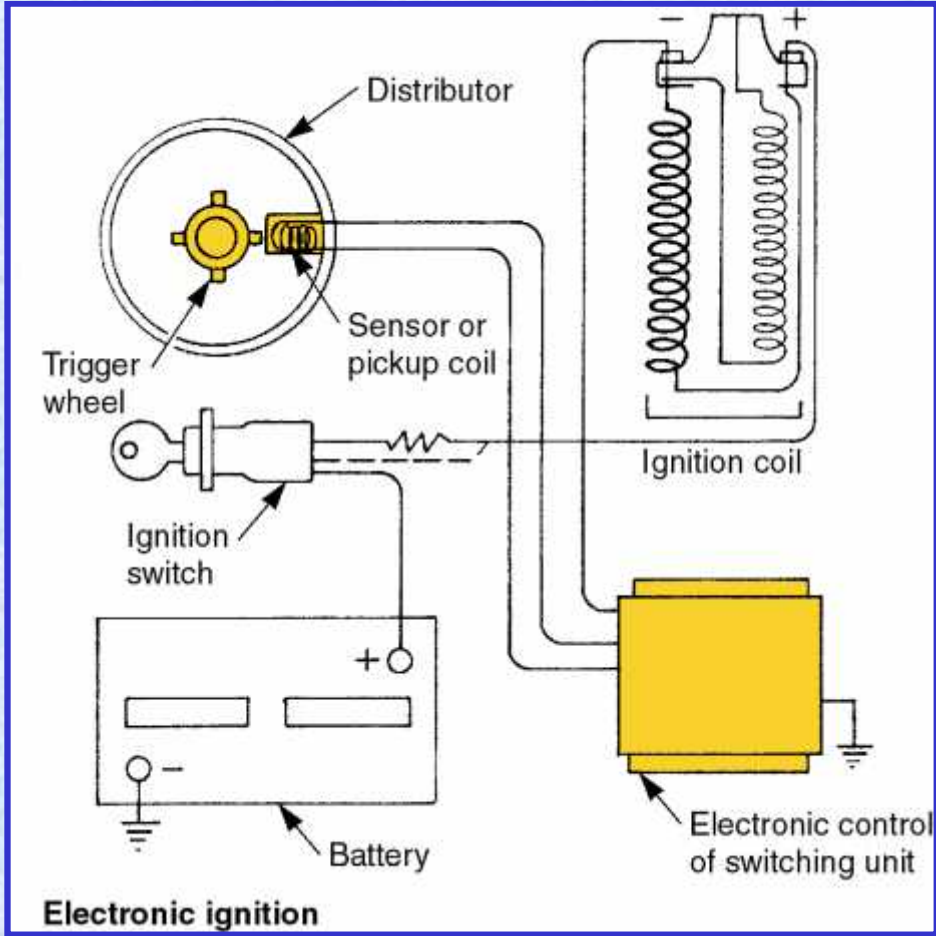
# Point Dwell (Cam Angle)

Amount of time, in degrees of distributor rotation, that the points remain closed between each opening





# Electronic Ignition System



# Electronic Ignition System

- ☐ Solid-state system
- ☐ Uses an ignition control module and a distributor pickup coil to operate the ignition coil
- ☐ No mechanical points to wear or burn
- ☐ Timing and dwell won't change as mileage accumulates
- ☐ Produces high voltages



# Trigger Wheel

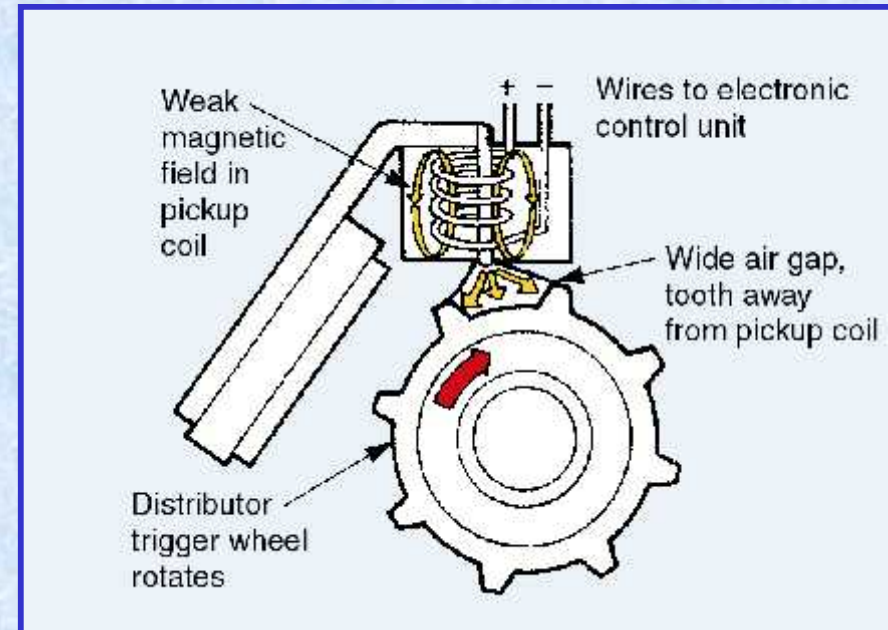
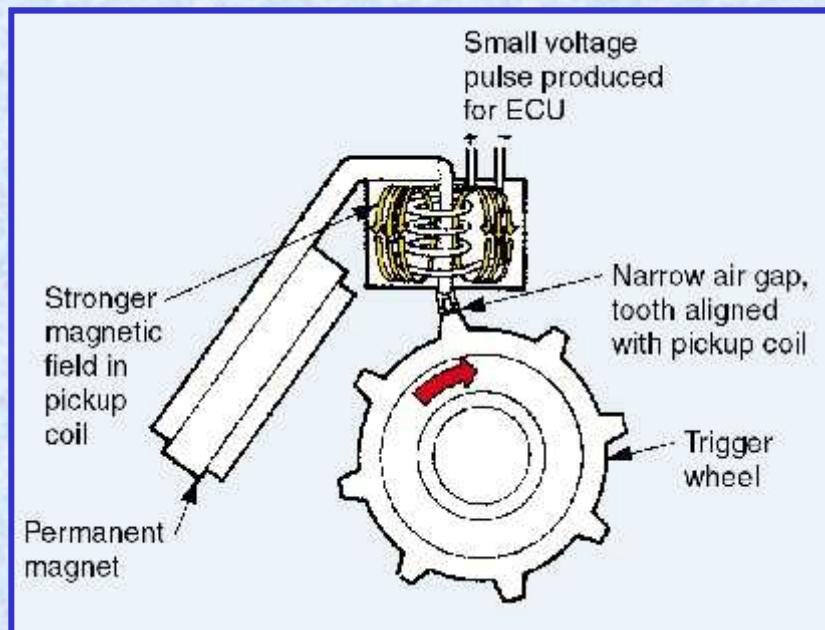
- ❑ Also referred to as the reluctor or pole piece
- ❑ It is fastened to the upper end of the distributor shaft
- ❑ It has one tooth for each engine cylinder

# Pickup Coil

- ❑ Small set of windings that form a coil
- ❑ Produces tiny voltage pulses that are sent to the ignition control module
- ❑ As the trigger wheel tooth passes the pickup coil, it changes the magnetic field
- ❑ Current is induced in the coil



# Pickup Coil Operation



# Hall-Effect Pickup

- ❑ Solid state chip
- ❑ Produces a signal when triggered by a slotted wheel
- ❑ A constant current is sent through the device
- ❑ A permanent magnet is located next to the Hall-effect chip

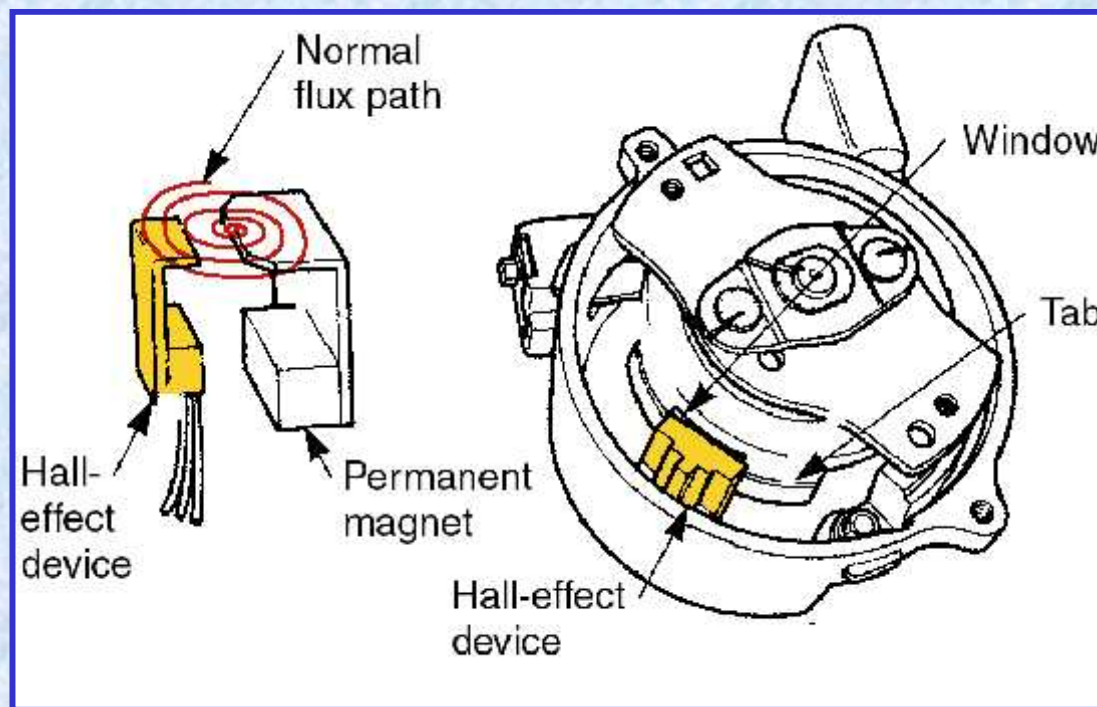


# Hall-Effect Operation

- ❑ When the magnetic field is blocked by the slotted wheel, the Hall-effect sensor switches off
- ❑ When the slotted wheel's tab moves out from between the magnet and sensor, the magnetism causes the sensor to turn on
- ❑ The signal generated by the sensor is used by the ignition control module

# Hall-Effect Operation

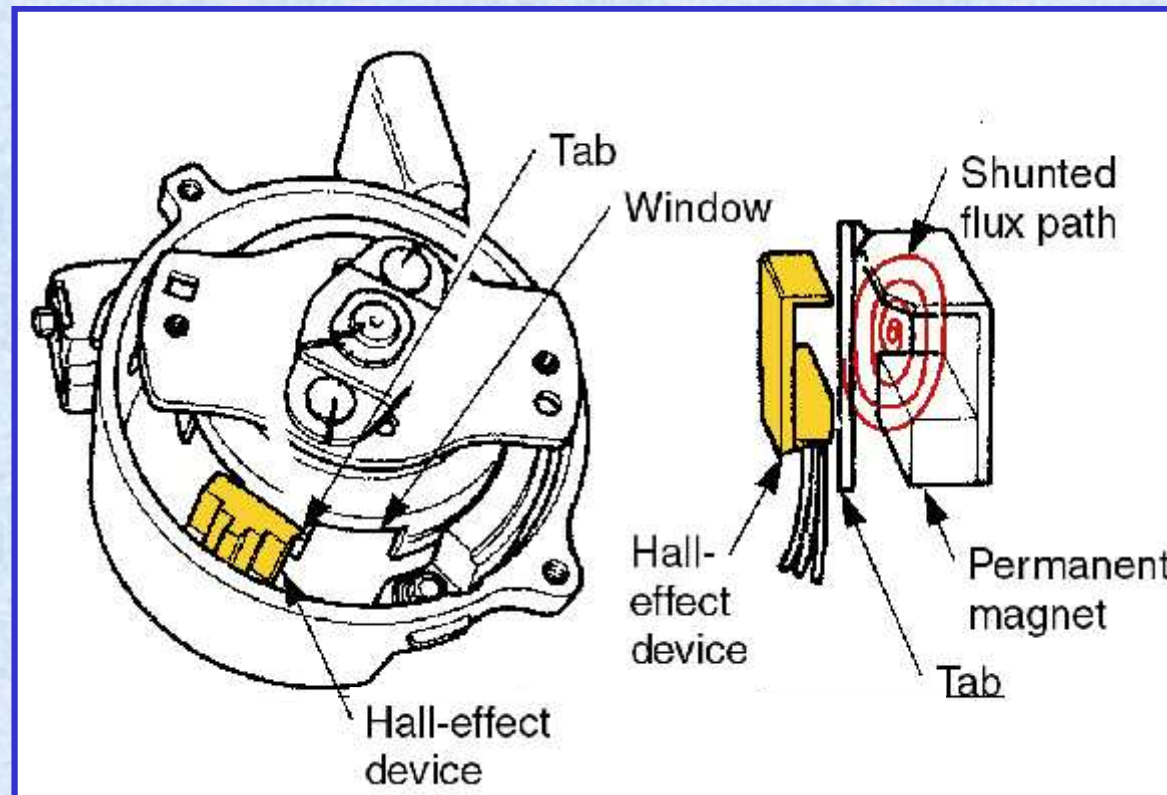
Window between magnet and sensor





# Hall-Effect Operation

Tab between magnet and sensor



# Optical Pickup

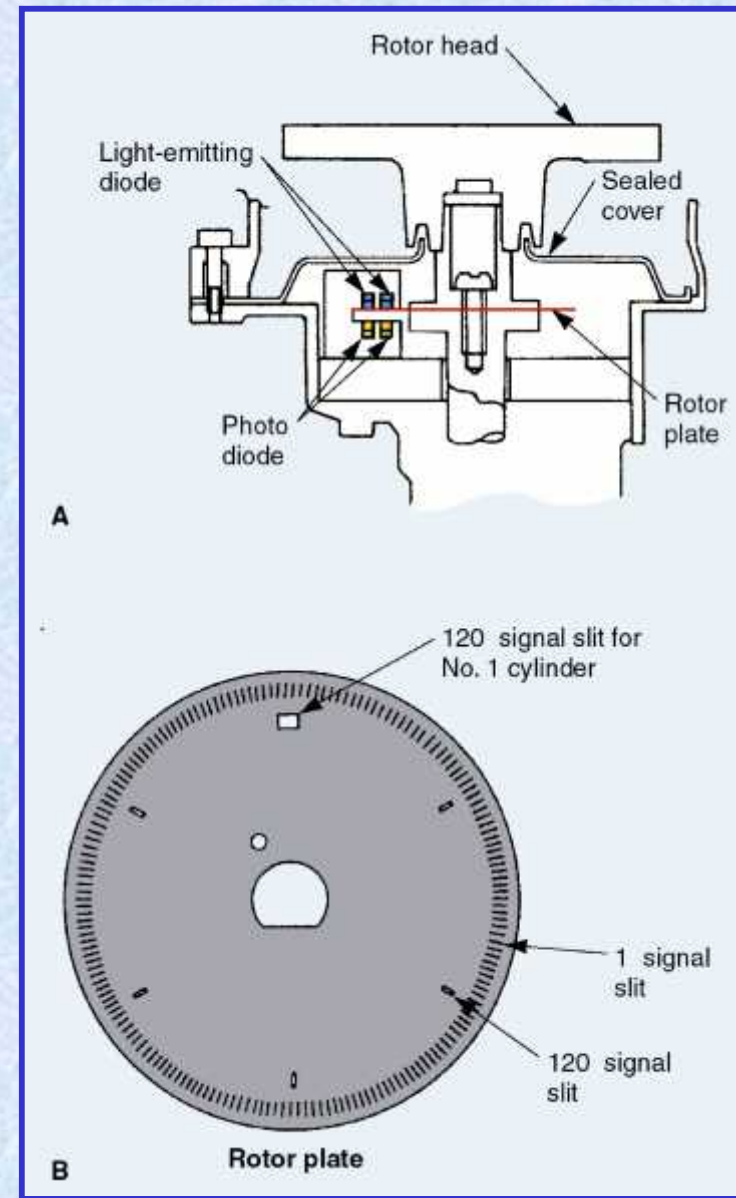
- ❑ Uses LEDs (light-emitting diodes) and photo diodes (light sensors)
- ❑ A slotted rotor plate rotates between the LEDs and the photo diodes
- ❑ When a slot passes between the diodes, light from the LEDs turns the photo diodes on



# Optical Pickup

A. LEDs shine light on the photo diodes

B. Rotor plate



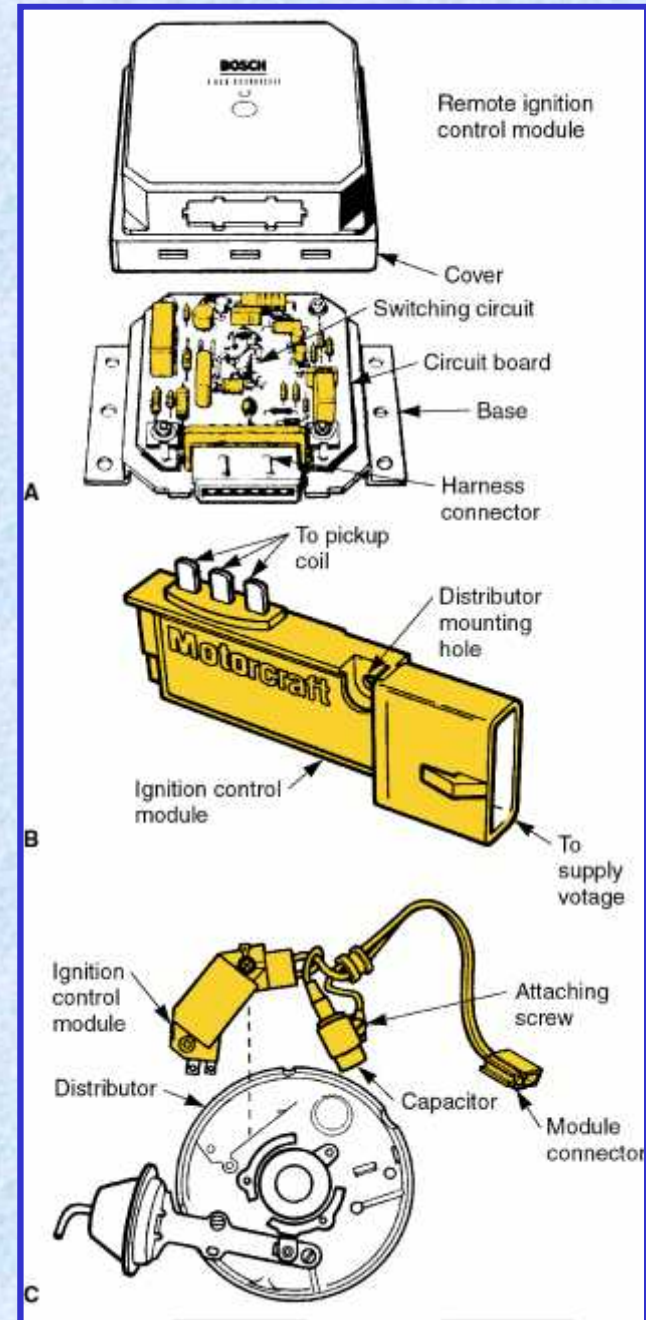
# Ignition Control Module

- ❑ Turns coil primary current on and off
- ❑ Locations
  - remote-mounted in engine compartment
  - on the side of the distributor
  - inside the distributor
  - under dash



# Ignition Control Module

- A. Remote-mounted
- B. Side of the distributor
- C. Inside the distributor

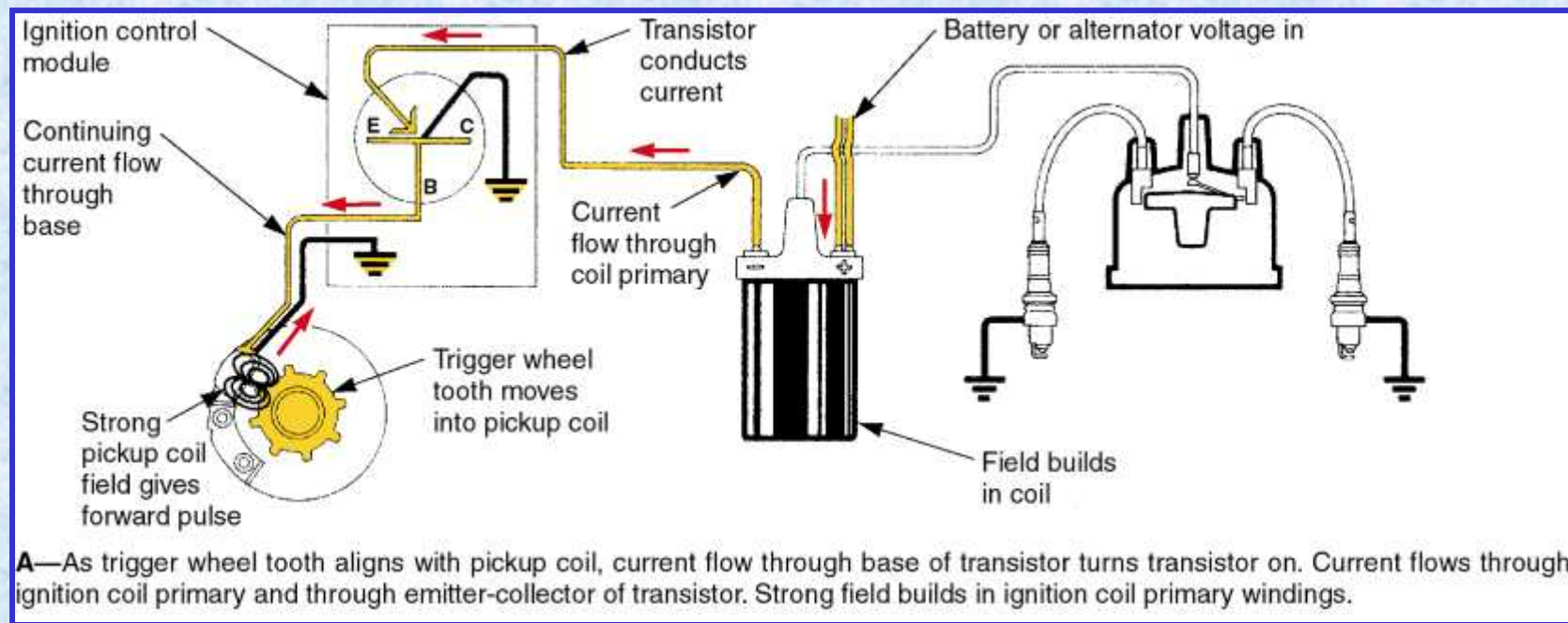


# Operation—Dwell

- ❑ As the trigger wheel approaches the pickup coil, voltage turns the module's transistor on
- ❑ Current flows through the coil's primary windings, building a strong magnetic field



# Operation—Dwell

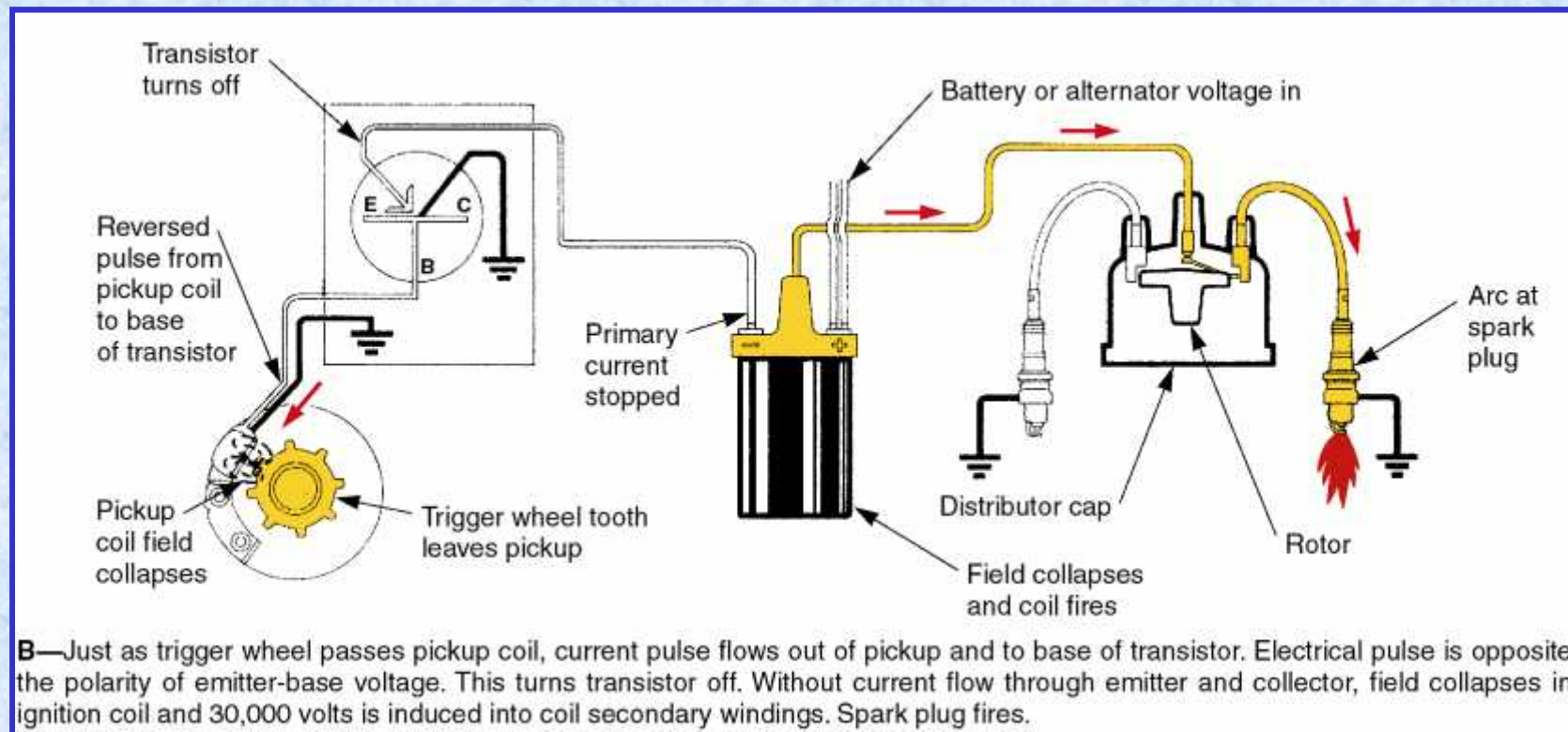


# Operation—Ignition

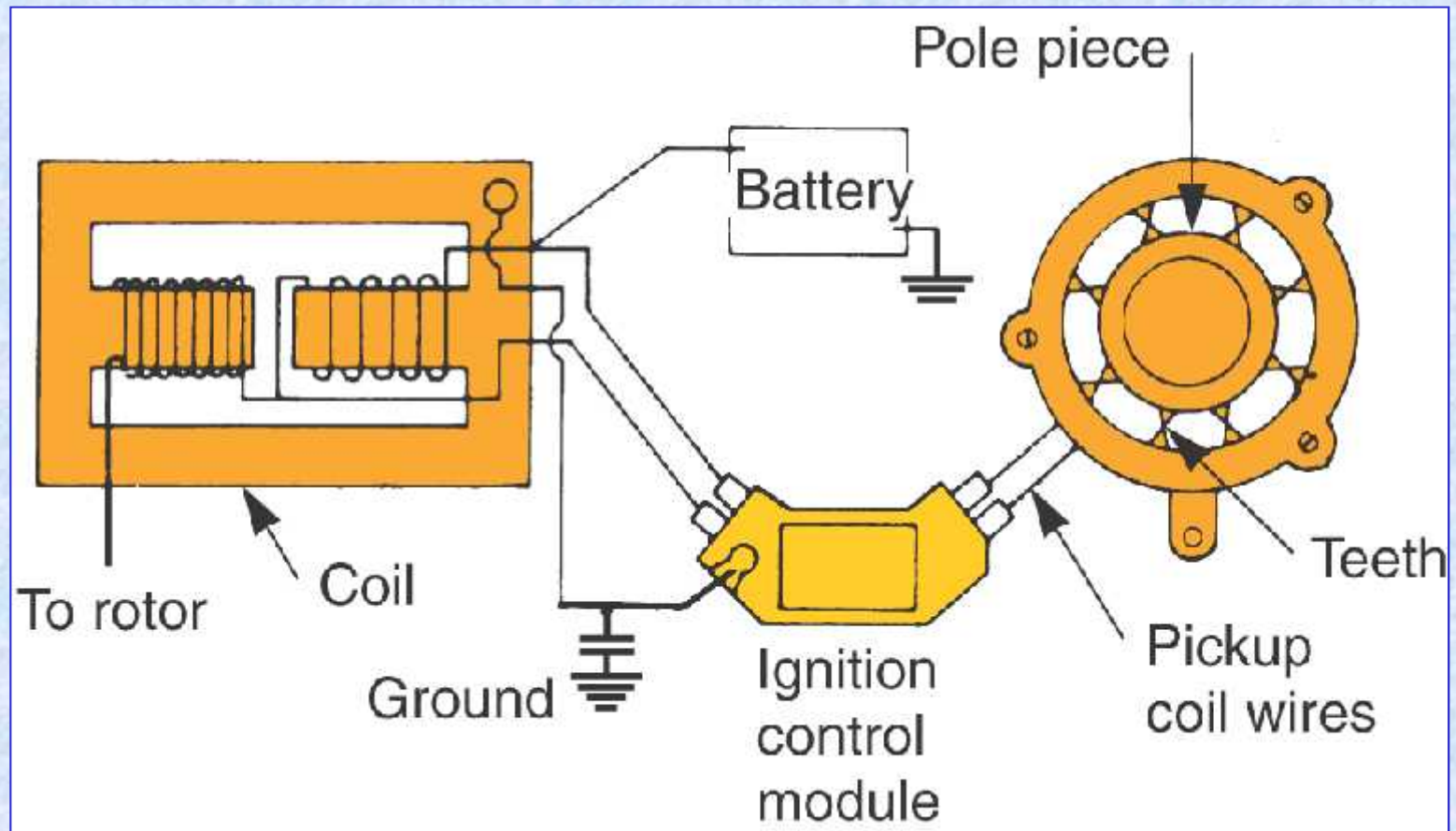
- ❑ As the trigger wheel passes the pickup coil, the changing pickup coil output turns the module's transistor off
- ❑ Current flow through the primary windings turns off
- ❑ The magnetic field collapses, cutting across the coil's secondary windings and inducing a high voltage in the secondary windings, causing a spark



# Operation—Ignition



# Module Connections



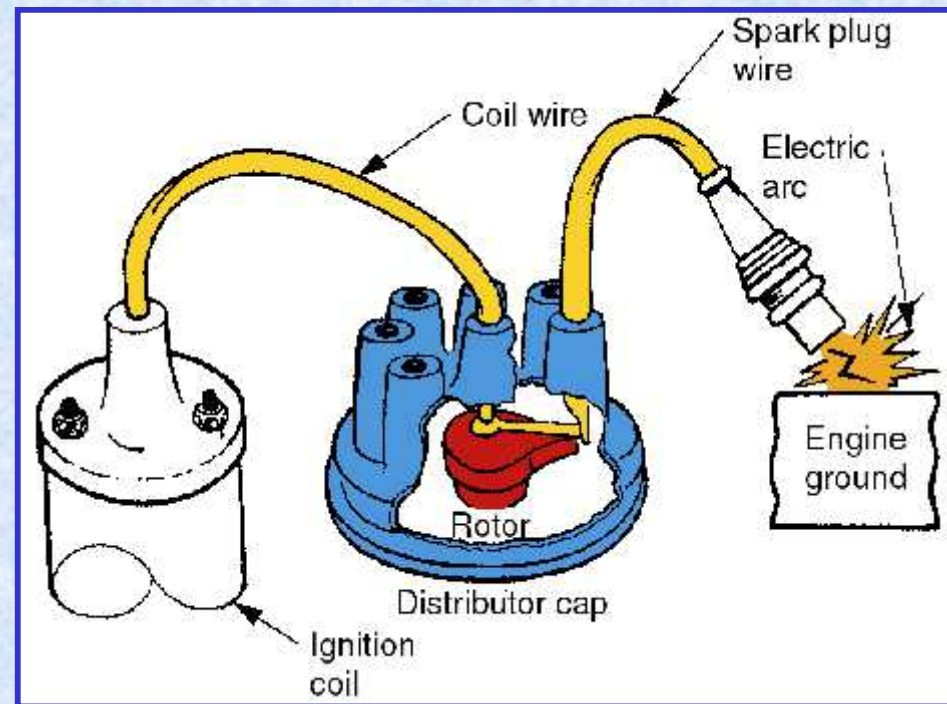


# Distributor Cap and Rotor

- ☐ Insulated plastic cap that fits over the distributor housing
- ☐ The center terminal carries current to the rotor
- ☐ The outer terminals carry current from the rotor to the spark plugs
- ☐ The rotor carries current from the center terminal to the outer terminals

# Distributor Cap and Rotor

The rotating rotor feeds high voltage to each spark plug wire



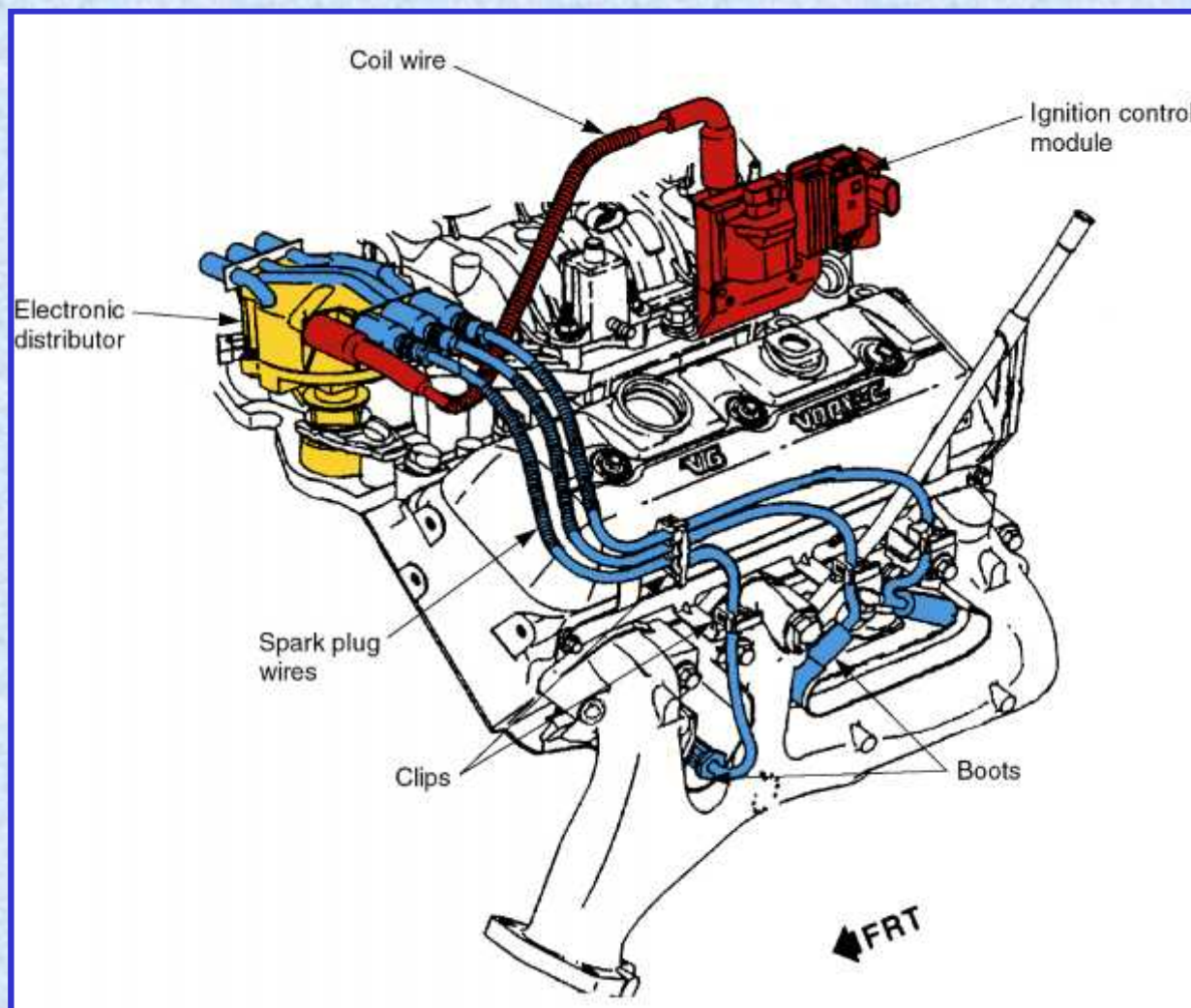


# Secondary Wires

- ❑ Carry current produced by the ignition coil
- ❑ Solid wires
  - wire conductor may cause radio interference
- ❑ Resistance wires
  - carbon-impregnated strands and rayon braids
  - about 10,000 ohms per foot
  - prevent radio noise

# Secondary Wires

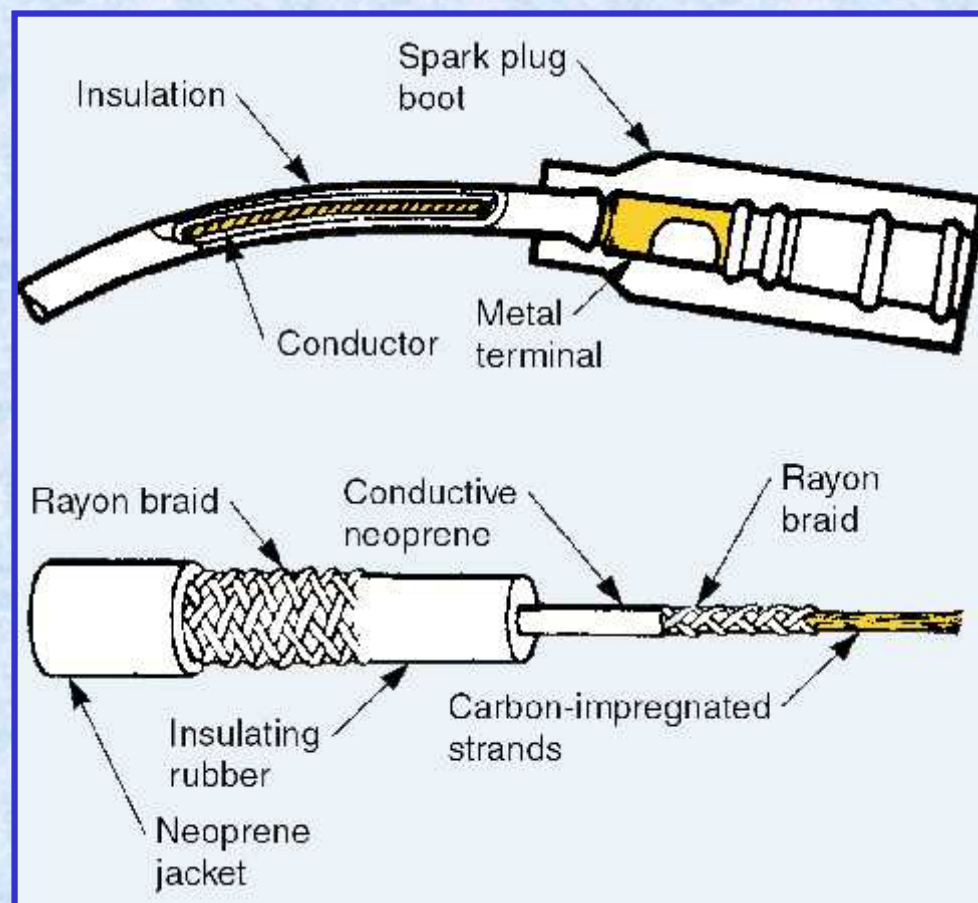
Clips secure the wires in place





# Secondary Wires

Carbon-impregnated strands prevent radio interference



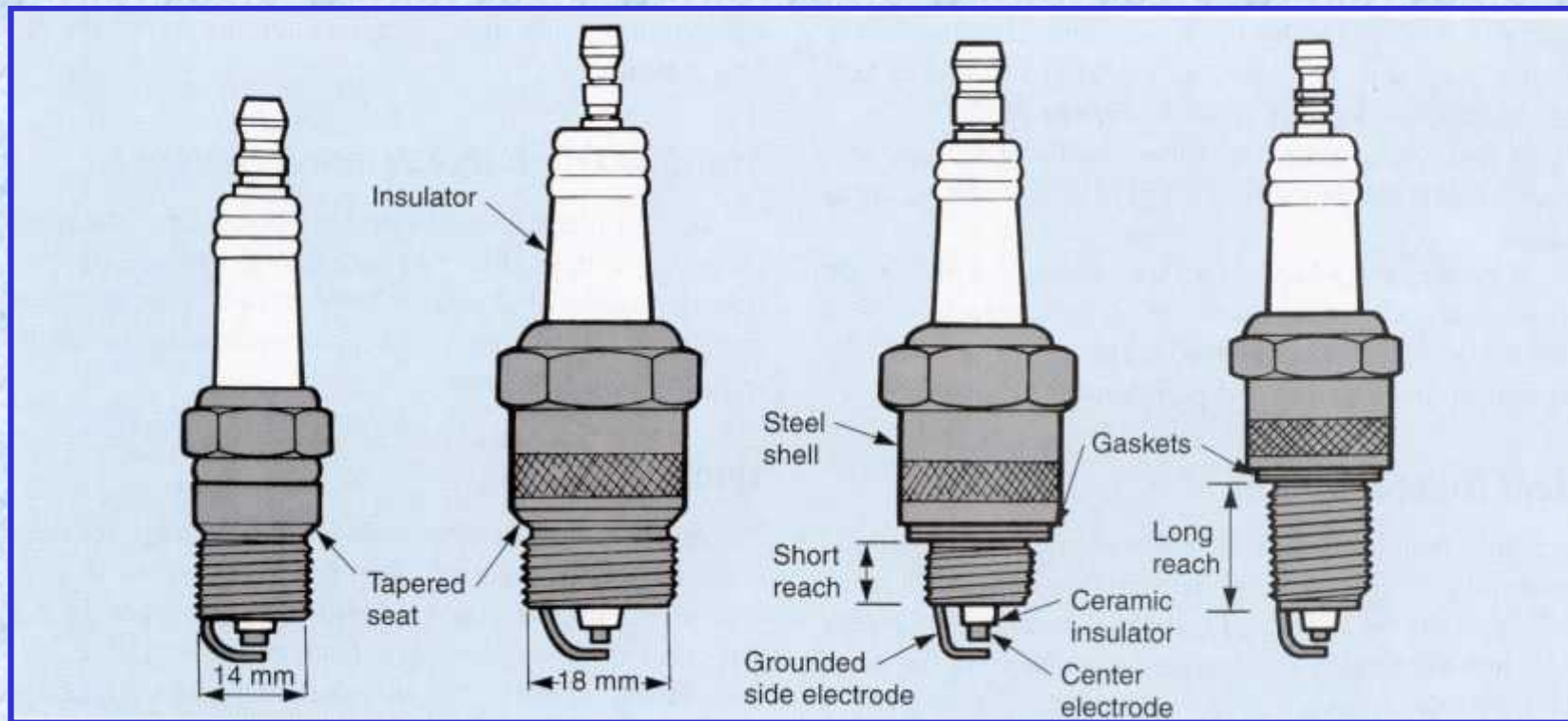
# Spark Plugs

- ❑ Use high voltage to ignite the fuel mixture
- ❑ 4000 to 28,000 volts make the current jump the gap between the electrodes



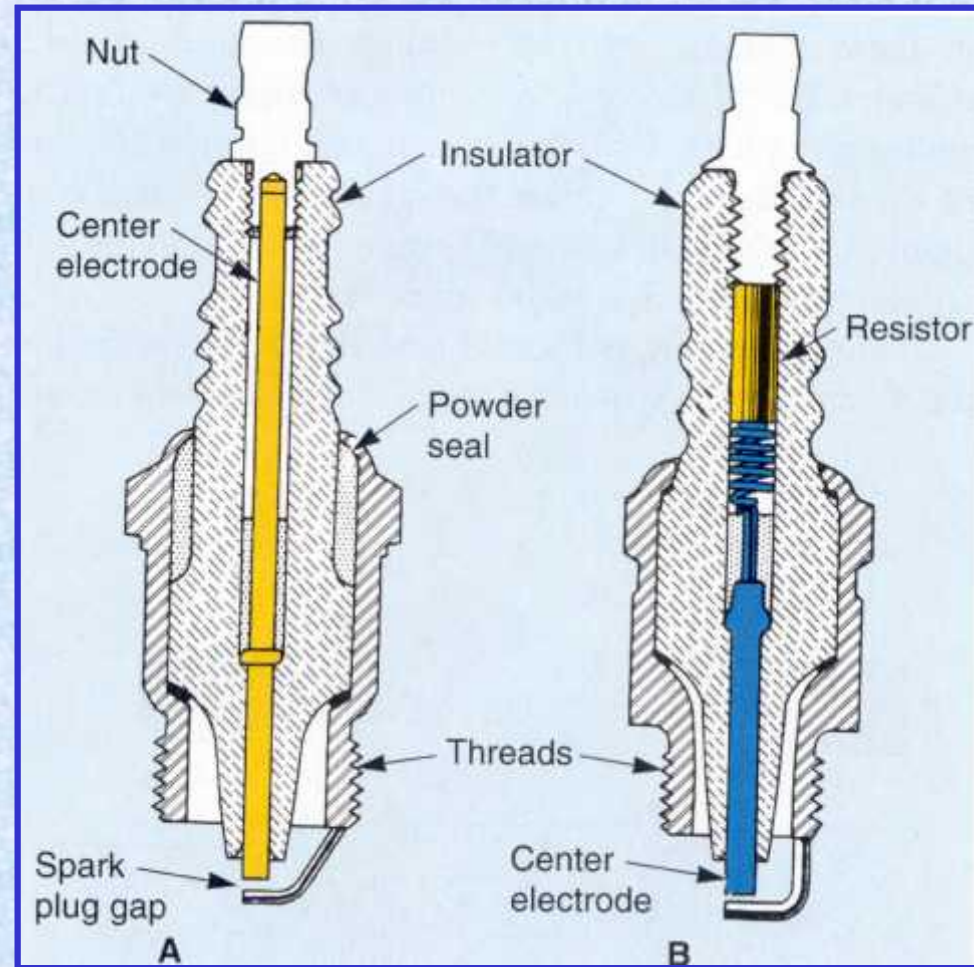
# Seat and Thread Design

14 mm is the most common size



# Spark Plugs

- A. Non-resistor
- B. Resistor

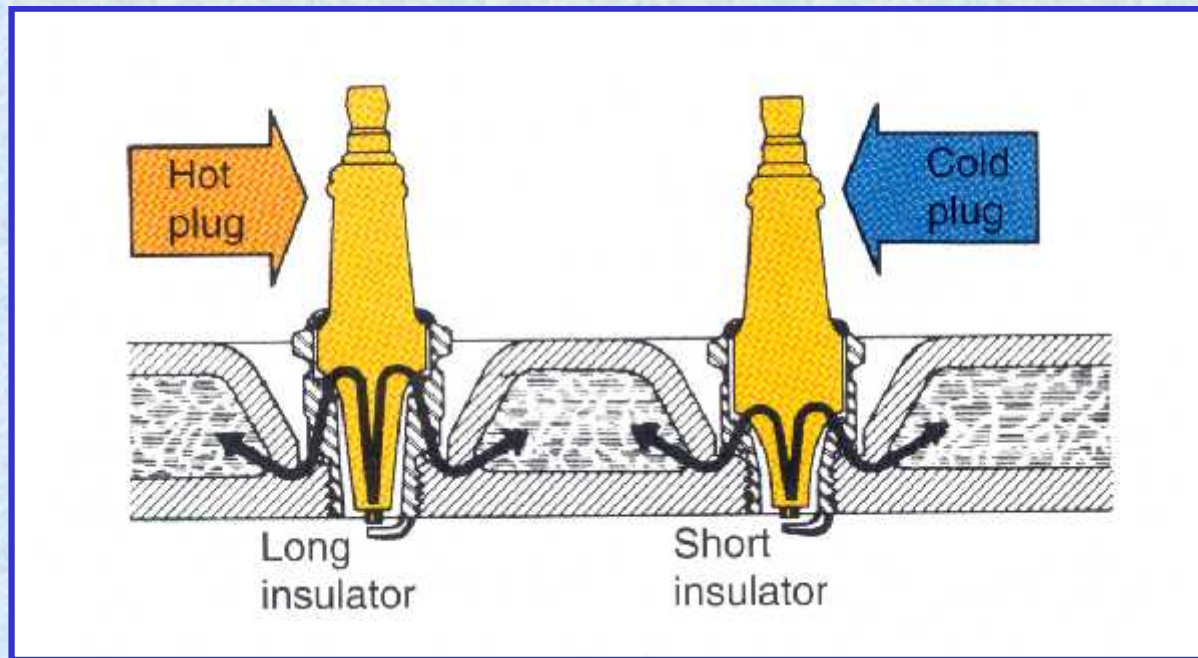




# Spark Plug Heat Range

- ❑ Hot spark plug
  - long insulator tip
  - self-cleaning action
- ❑ Cold spark plug
  - shorter insulator tip
  - used in high speed engines
  - prevents tip overheating and preignition

# Spark Plug Heat Range





# Multiple Discharge Ignition

- ☐ Fires the spark plugs more than once on each power stroke
- ☐ Promotes the complete burning of the fuel charge
- ☐ Often used on racing engines

# Ignition Timing

- ❑ Spark timing
- ❑ How early or late the spark plugs fire in relation to piston position
- ❑ Changes with speed, load, and temperature



# Timing Advance

- ❑ The plugs fire earlier, before top dead center (BTDC)
- ❑ Gives combustion enough time to develop pressure on the power stroke

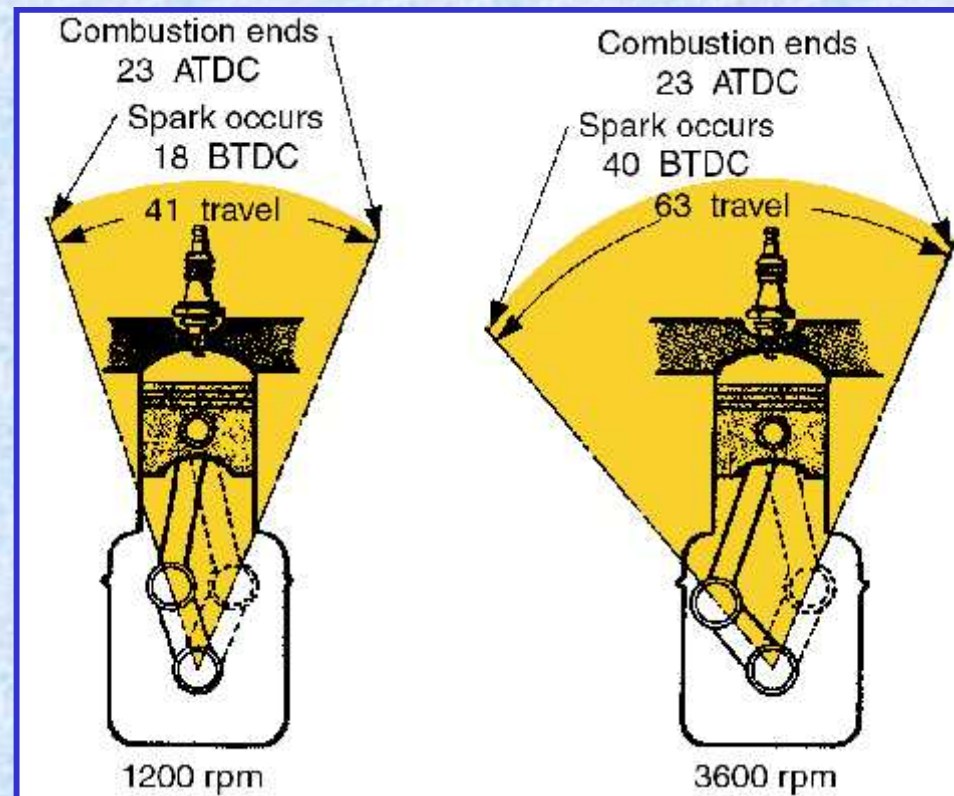
# Timing Retard

- ☐ The plugs fire later
- ☐ Used in low speed, high load conditions
- ☐ Prevents spark knock or ping

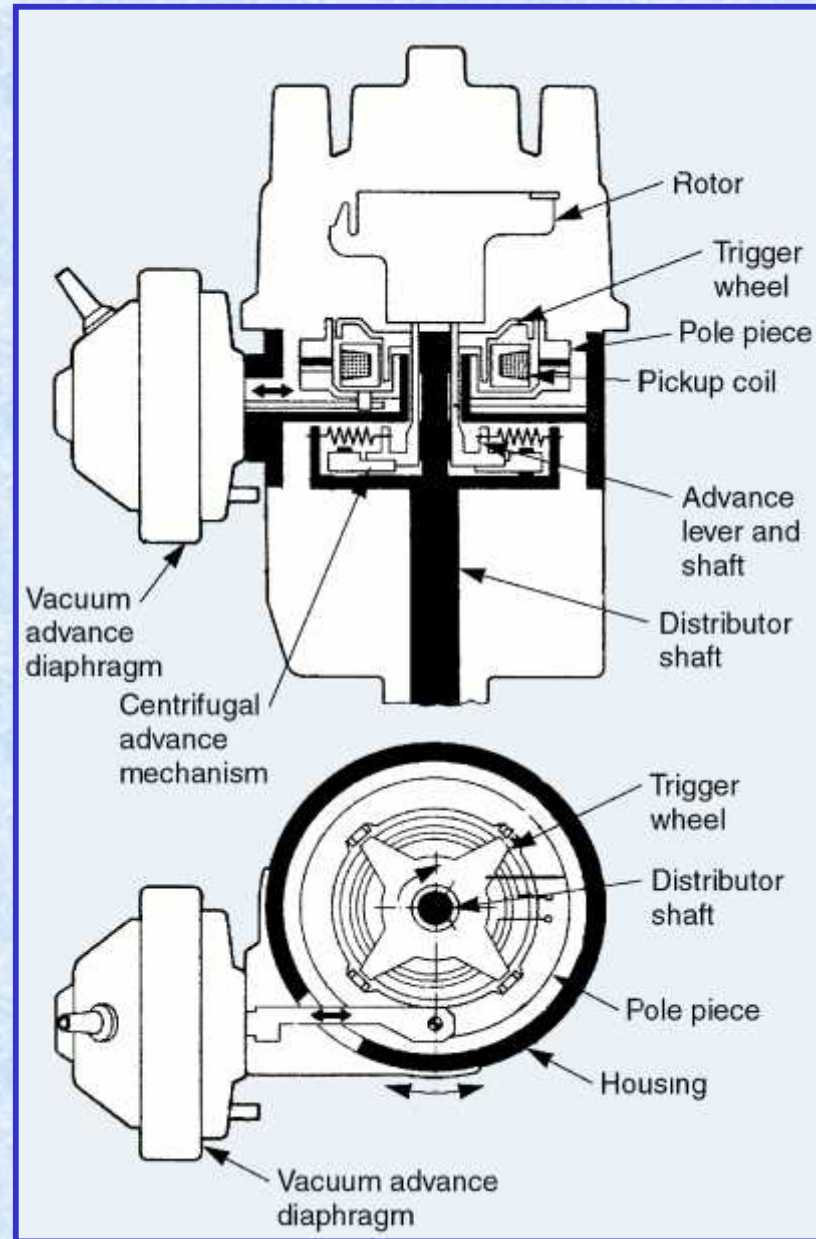


# Ignition Timing

Combustion starts sooner at high rpm to ensure that all fuel burns on power stroke



# Advance Mechanisms

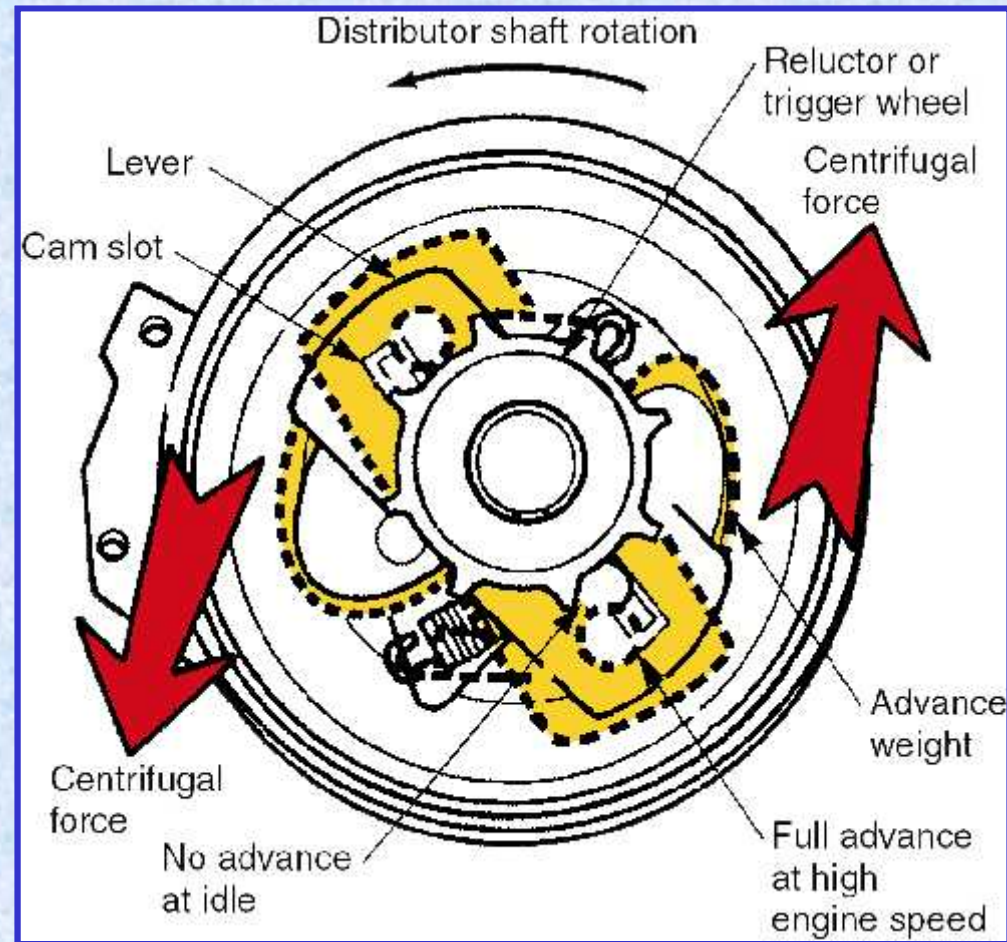




# Centrifugal Advance

- ☐ At low speeds, small springs hold the advance weights inward
- ☐ The timing is retarded
- ☐ As speed increases, the weights are thrown outward, rotating the distributor cam or trigger wheel against distributor rotation
- ☐ The timing is advanced

# Centrifugal Advance

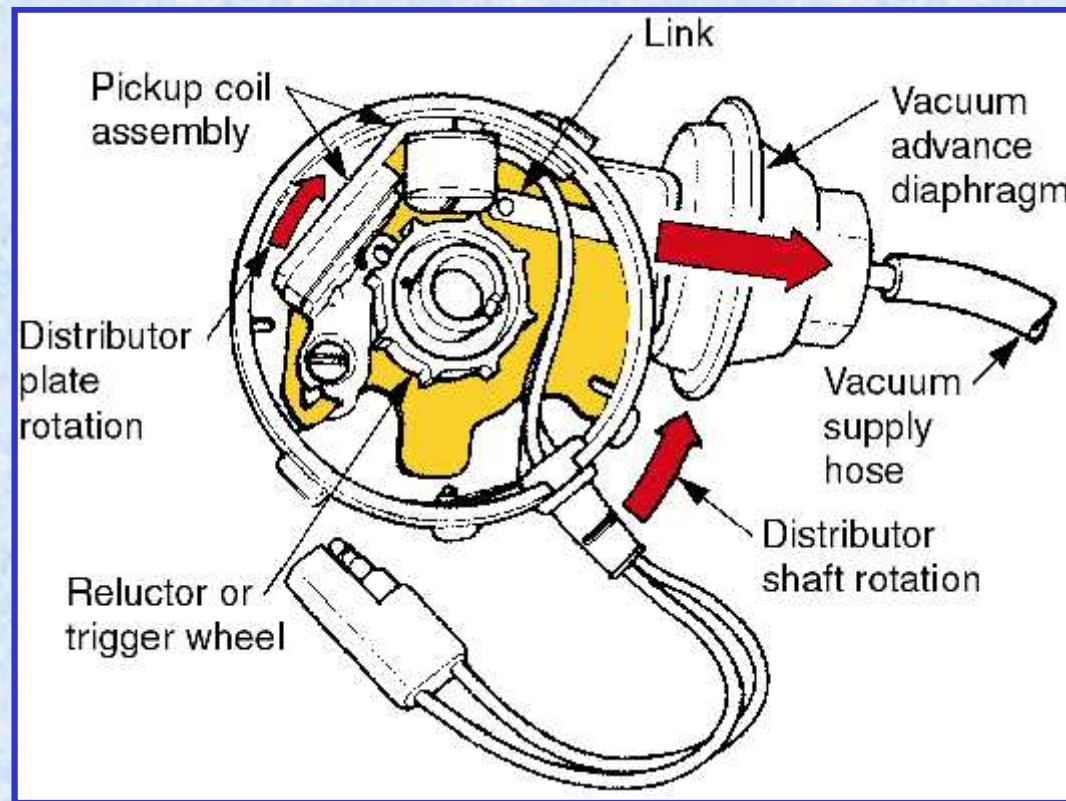




# Vacuum Advance

- ☐ At idle, ported vacuum is not present, spark timing is not advanced
- ☐ At part throttle, ported vacuum pulls distributor diaphragm, rotating distributor plate against distributor rotation, spark timing is advanced
- ☐ At full throttle, vacuum drops, retarding timing

# Vacuum Advance

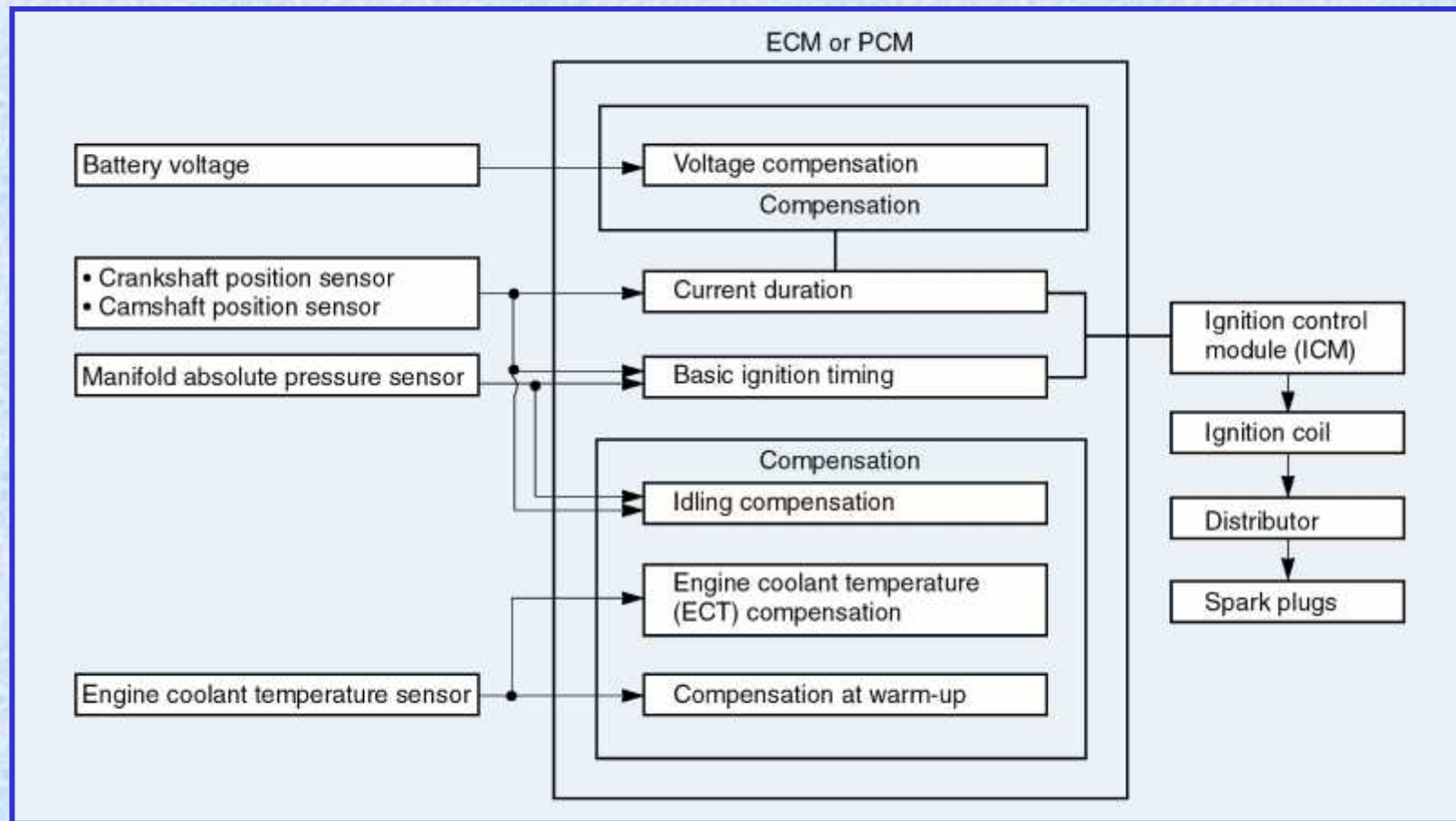




# Electronic Spark Advance

- ❑ Computer-controlled timing advance
- ❑ Sensors used:
  - crankshaft and camshaft position
  - manifold absolute pressure (load)
  - throttle position
  - intake air and coolant temperatures
  - knock (spark knock)

# Electronic Spark Advance

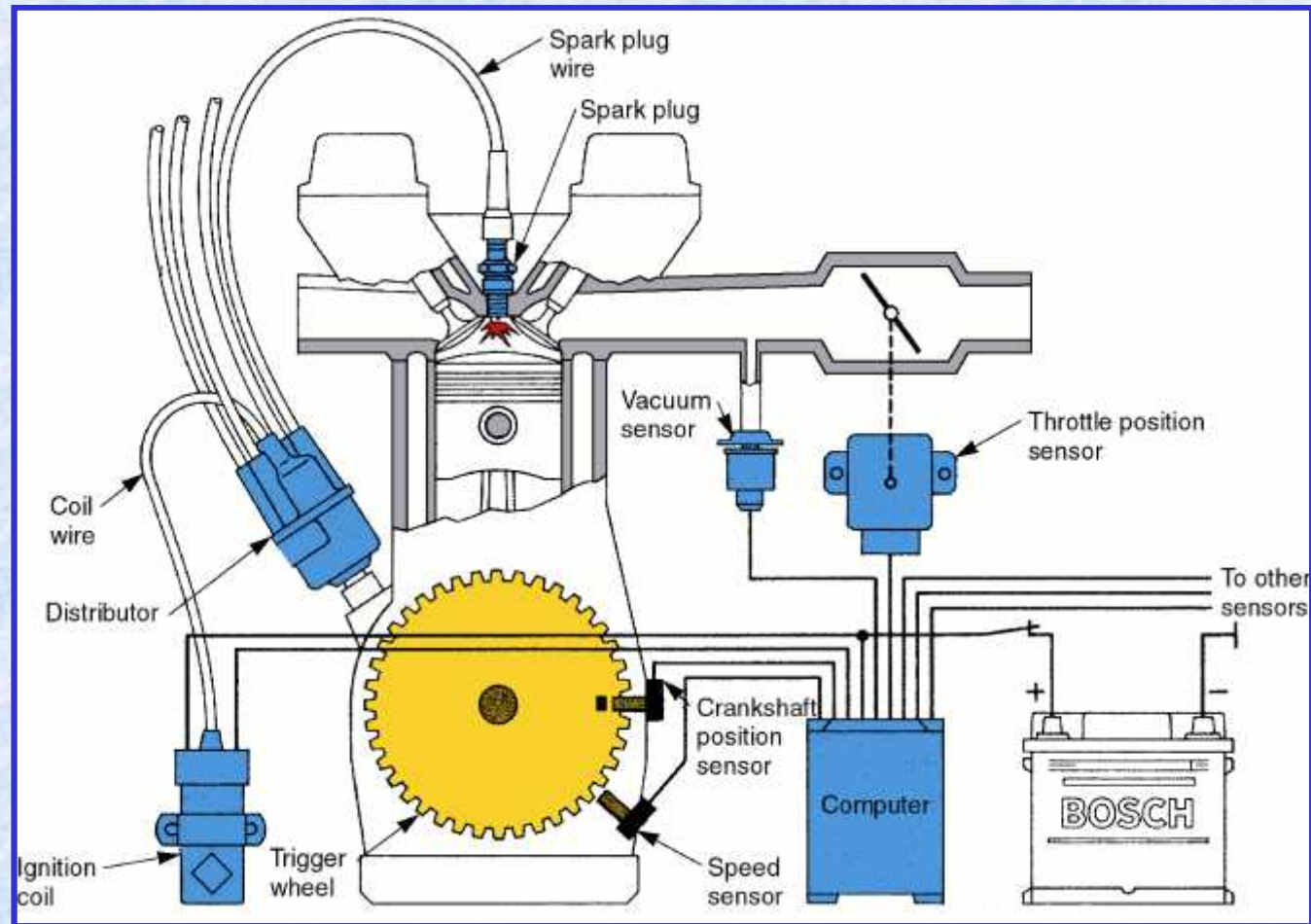




# Crankshaft-Triggered Ignition

- ❑ Maintains more precise timing than a distributor-mounted pickup coil
  - no backlash in the distributor drive gear, timing chain, or gears
- ❑ The crankshaft position is “read” off the crankshaft

# Crankshaft-Triggered Ignition





# Crankshaft Position Sensor

- ☐ Mounted next to the trigger wheel
- ☐ Sends electrical pulses to the computer
- ☐ As the crankshaft turns, the crankshaft position sensor signals the crankshaft's speed and position
- ☐ If used, the distributor simply transfers high voltage to each spark plug

# Distributorless Ignition System

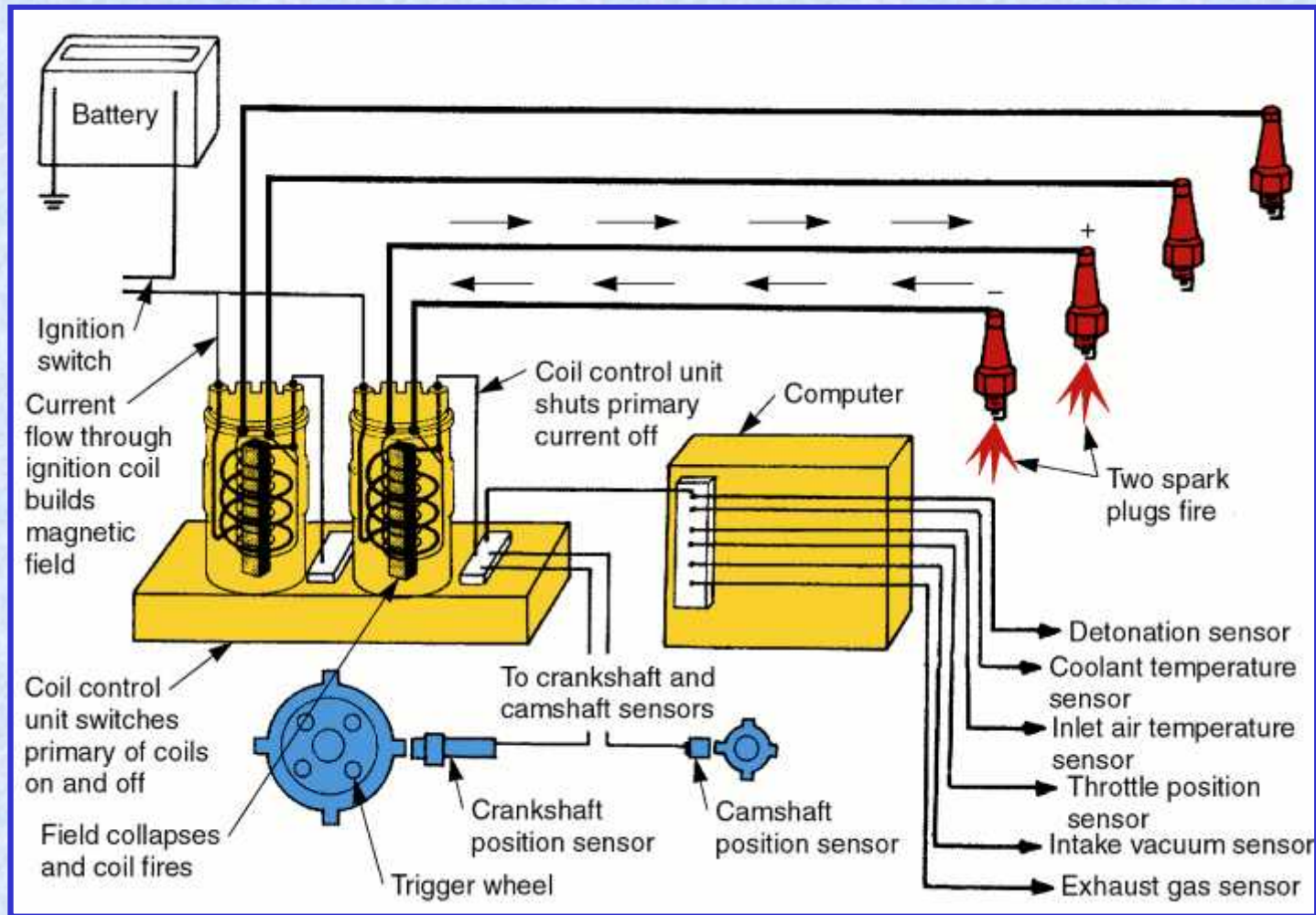
- ❑ Uses multiple coils, a coil control unit, engine sensors, and a computer to operate the spark plugs
- ❑ The coils fire two spark plugs at once
  - one on power stroke
  - one on exhaust stroke



# Operation

- ❑ The crankshaft and camshaft position sensors send signals to the coil control unit and the computer
- ❑ The computer signals the coil control unit when to fire the plugs (timing advance)
- ❑ The coil control unit sequences the coils, firing 2 plugs at a time

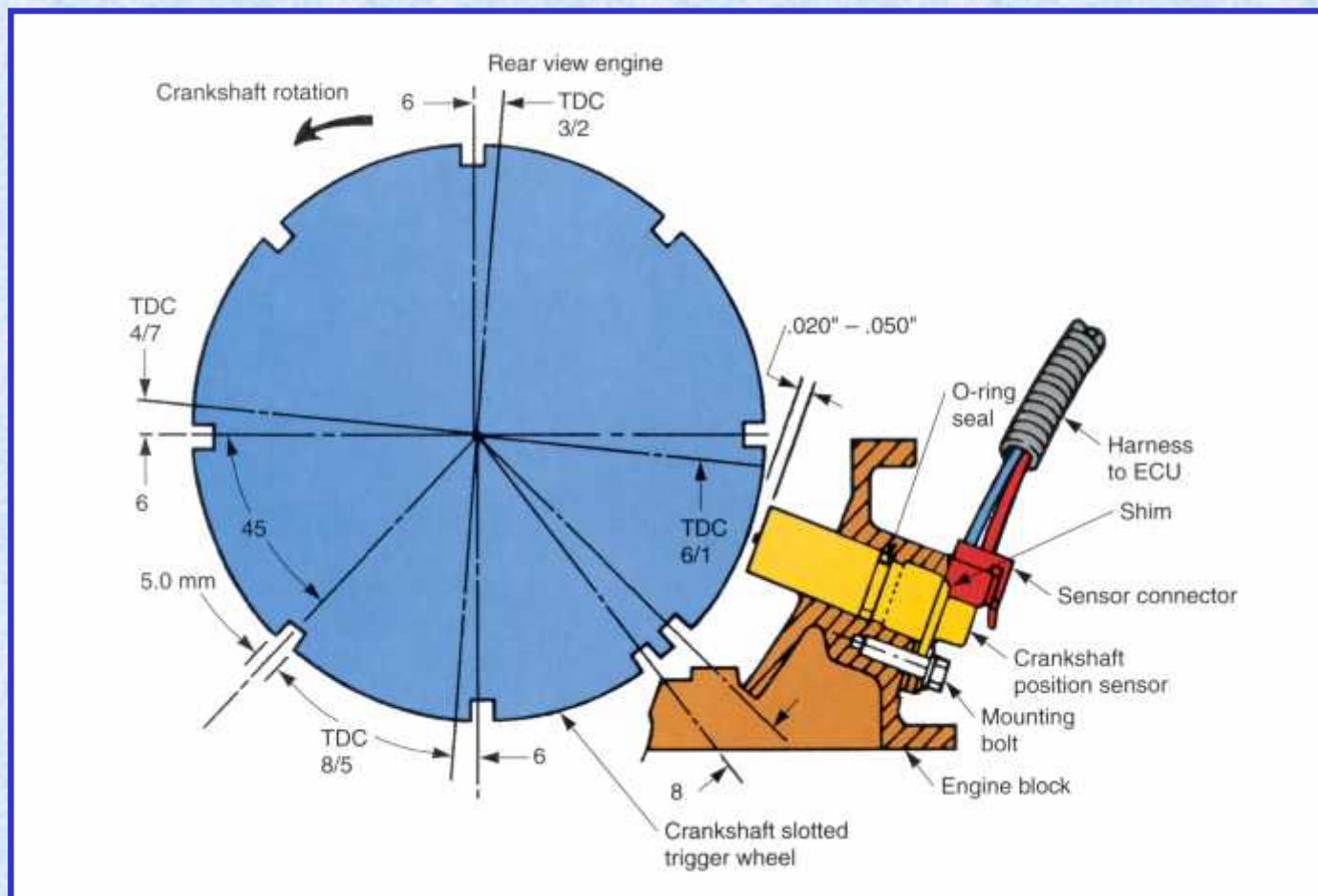
# Operation





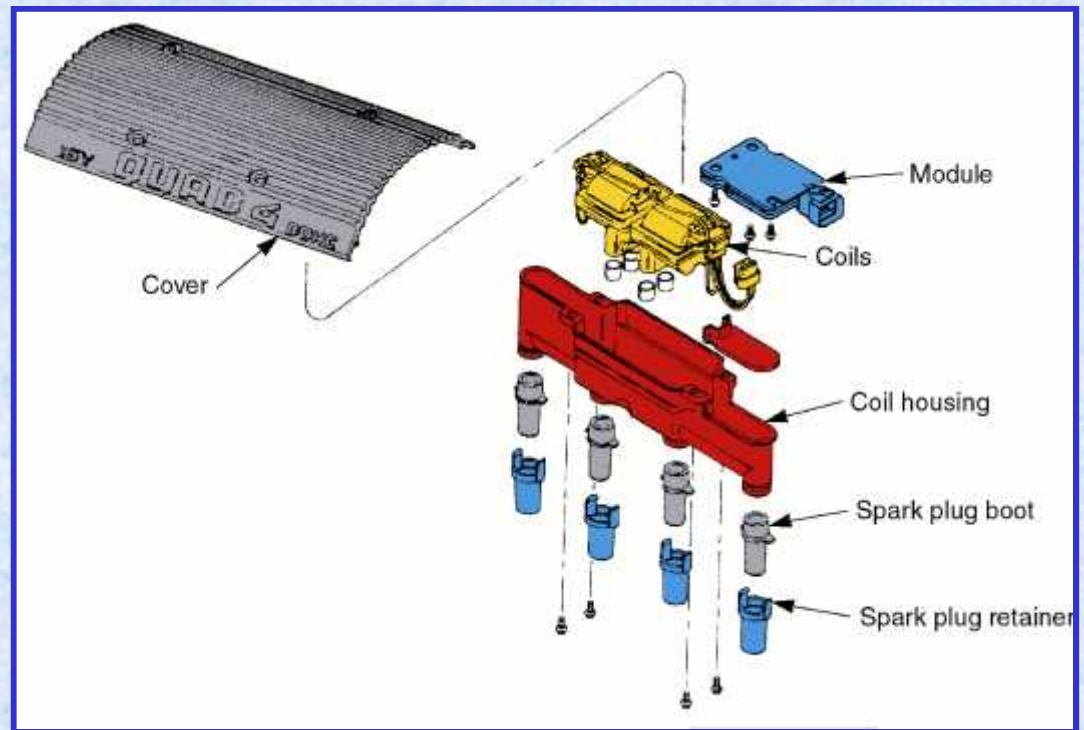
# Crankshaft Position Sensor

This trigger wheel is part of the crankshaft



# Distributorless Ignition System

Two coils are needed for a four-cylinder engine



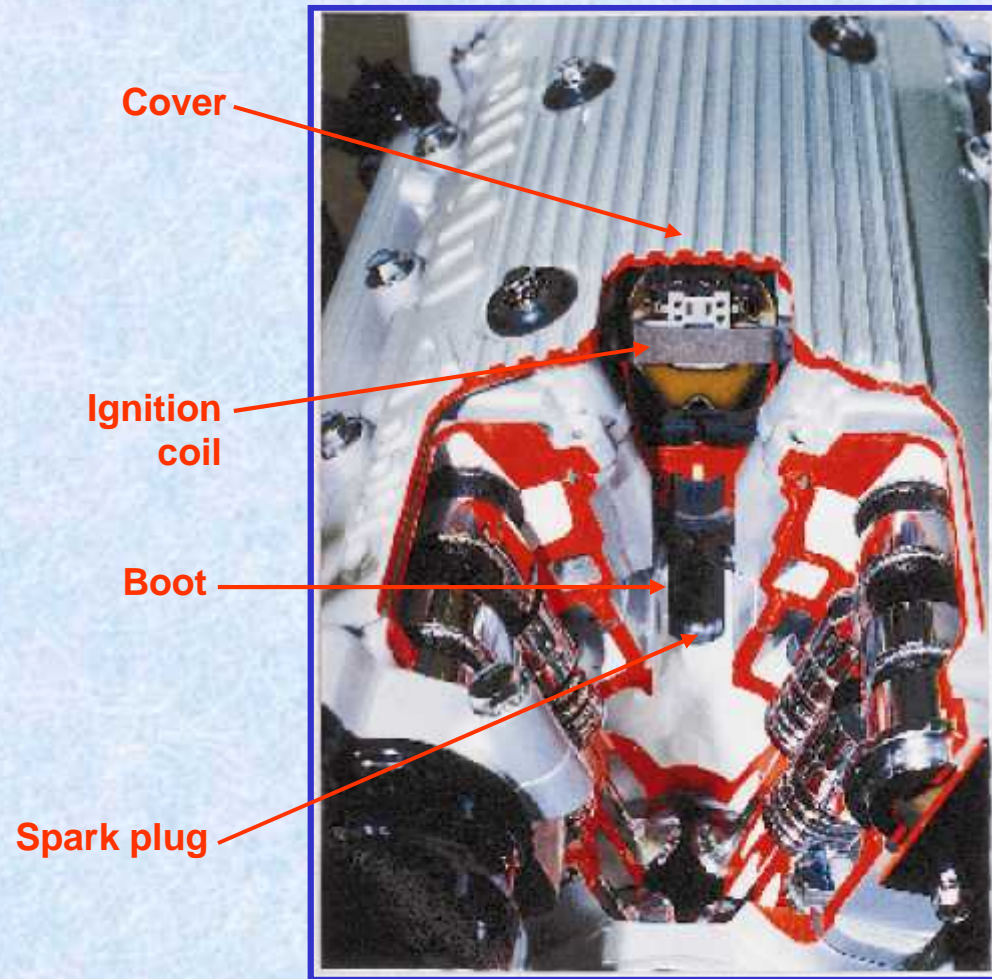


# Direct Ignition System

- ☐ An ignition coil mounted over each spark plug
- ☐ No conductor strip or plug wire
- ☐ Plugs only fire on the power stroke
- ☐ Plugs do not fire on the exhaust stroke

# Direct Ignition System

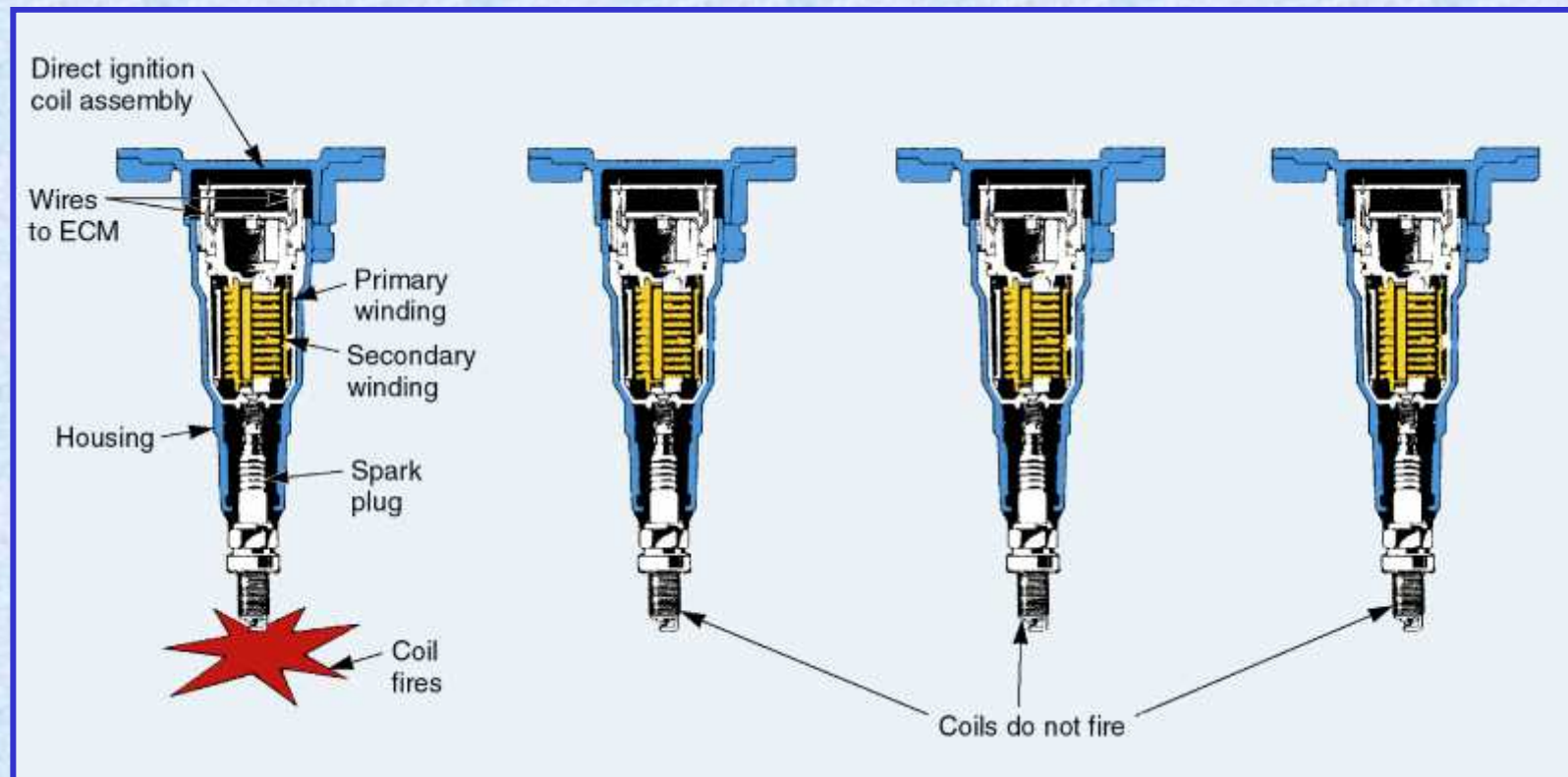
The coil is mounted over a spark plug





# Direct Ignition System

Four coils are needed for a four-cylinder engine



# Ionization Knock Sensing

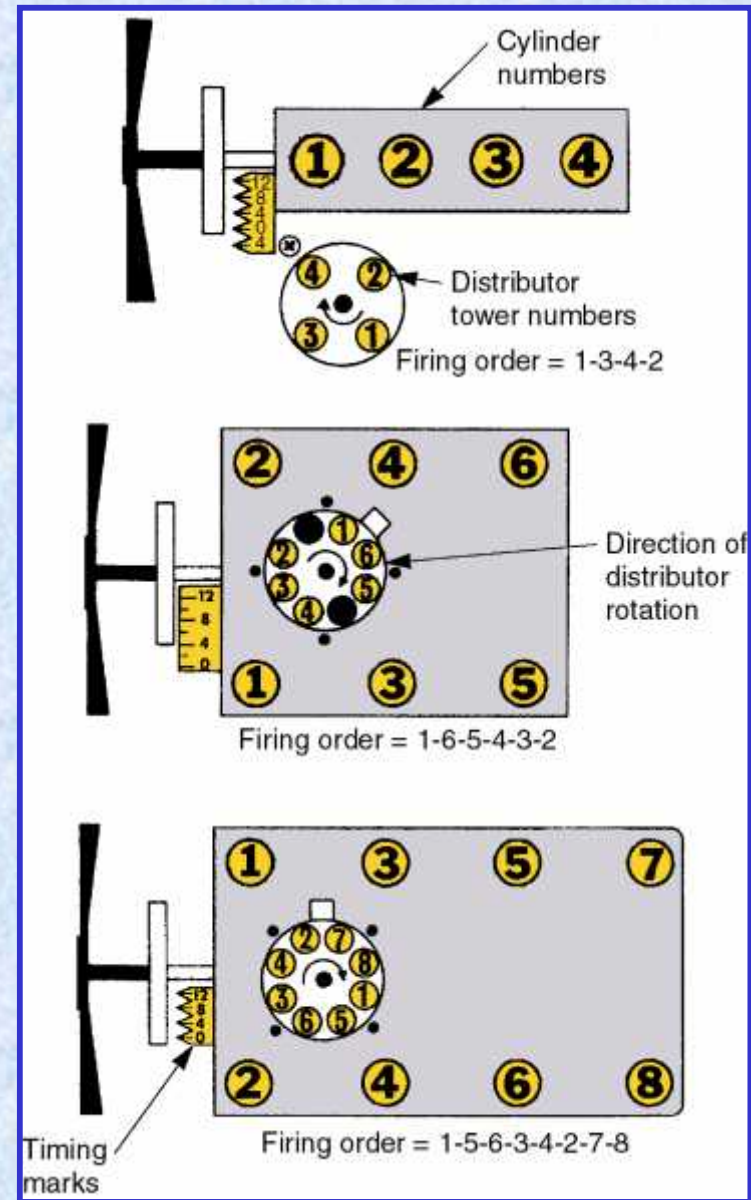
- ❑ Detects abnormal combustion and knocking
- ❑ The computer prompts the coil to send a low-voltage discharge across the spark plug after ignition
- ❑ The quality of combustion affects the resistance across the plug gap by varying the degree of ionization
- ❑ The computer uses feedback from this discharge to identify a knock



# Engine Firing Order

- ❑ Sequence in which the spark plugs fire
- ❑ Sometimes cast into the intake manifold
- ❑ Firing order information is used when installing plug wires, installing a distributor, setting ignition timing, and performing other tasks

# Distributor Ignition Firing Orders





# Distributorless Ignition Firing Order

