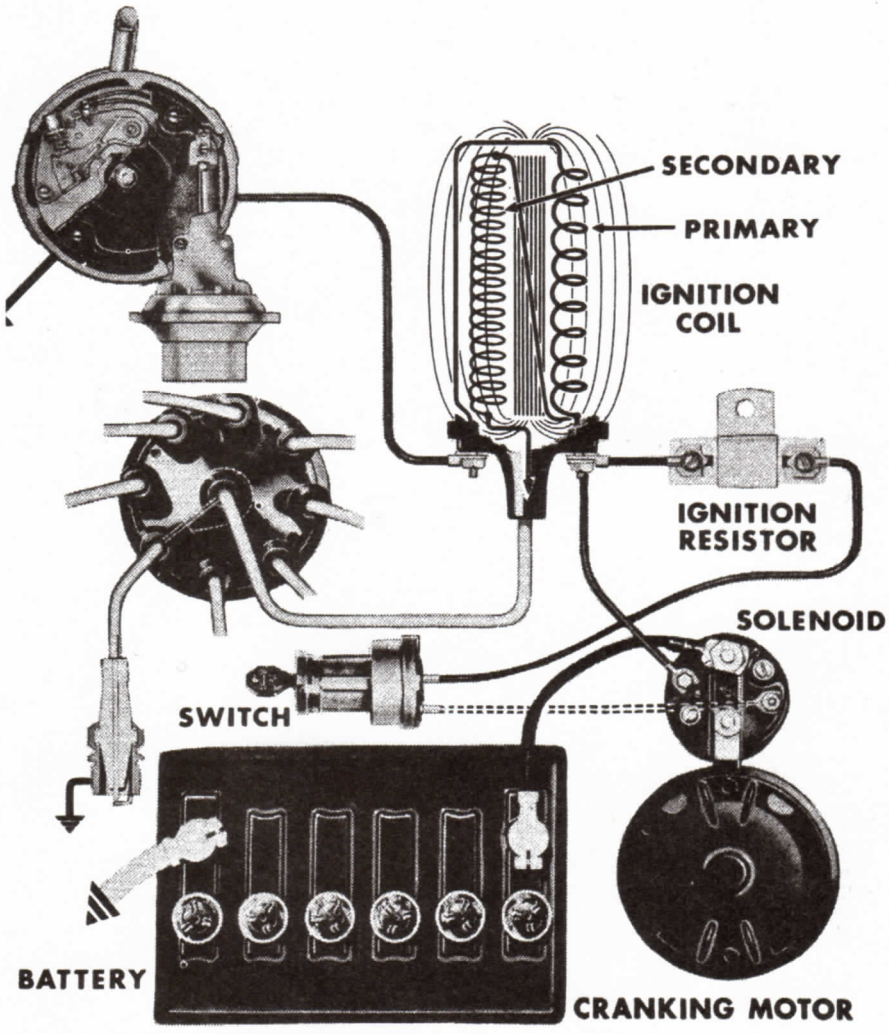


It Starts With A Spark

JOHN GIVES A DETAILED LOOK AT WHERE THE SPARKS COME FROM

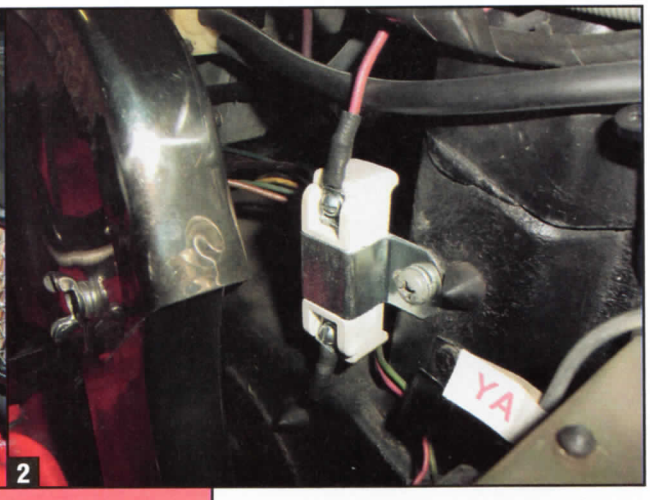
BY JOHN HINCKLEY

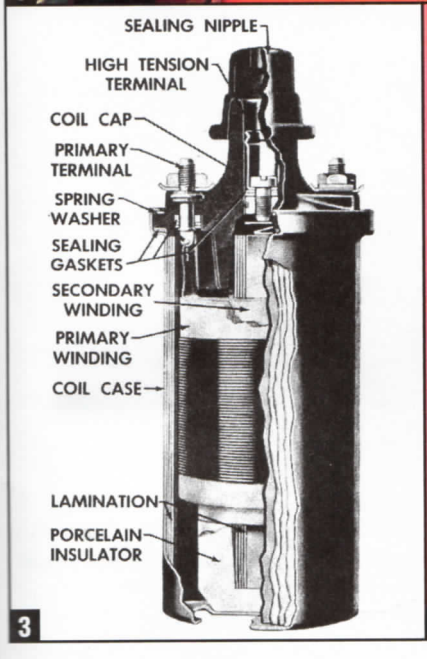
Most '50s, '60s, and '70s Corvette owners have tuned-up their cars, doing the "plugs-points-condenser" routine, set the dwell and checked the timing, and derive pride and satisfaction in maintaining their car themselves. However, not all of them really understand how their ignition system works—"where the sparks come from," and what part each ignition component plays in creating and distributing that spark energy.

This month, we'll dissect the ignition system and examine what happens between the ignition switch and the spark plugs that changes the battery's 12 volts to the 20,000-volt arc that "lights the fire" in the combustion chambers 12,000 times per minute. Understanding how the "system" and each of its components works will help diagnose it and keep it operating at peak efficiency.

HISTORY: In the infancy of the industry, before any of us were born and before reliable batteries were invented, the earliest cars used magneto ignition systems, with magnets embedded in the flywheel to create electrical current and spark energy. This is the same system still used today for lawnmowers, leaf blowers, chain saws, and other devices with small single-cylinder engines. Magnetos are also used on aircraft piston engines so their ignition systems aren't dependent on batteries for power. Interestingly enough, the magneto system is also used on Top Fuel Dragsters and Funny Cars, but they use dual magnetos that cost $8,000 each and have to have their rare-earth magnets recharged regularly.

The first reliable battery-operated ignition system was invented by Charles "Boss" Kettering, who ran a small General Motors operation called the Dayton Engineering Laboratories Company, later renamed DELCO. Kettering also





1 Most of your ignition system hides under your shielding; this month we'll dissect it and explain how it really works.

2 The ballast resistor typical of Corvettes through 1967; 1968-1974 Corvettes used a special cloth-covered resistance wire instead.

3 The coil is the heart of the ignition system; its primary and secondary windings create the 20,000 volts required to jump the gap at the spark plugs.

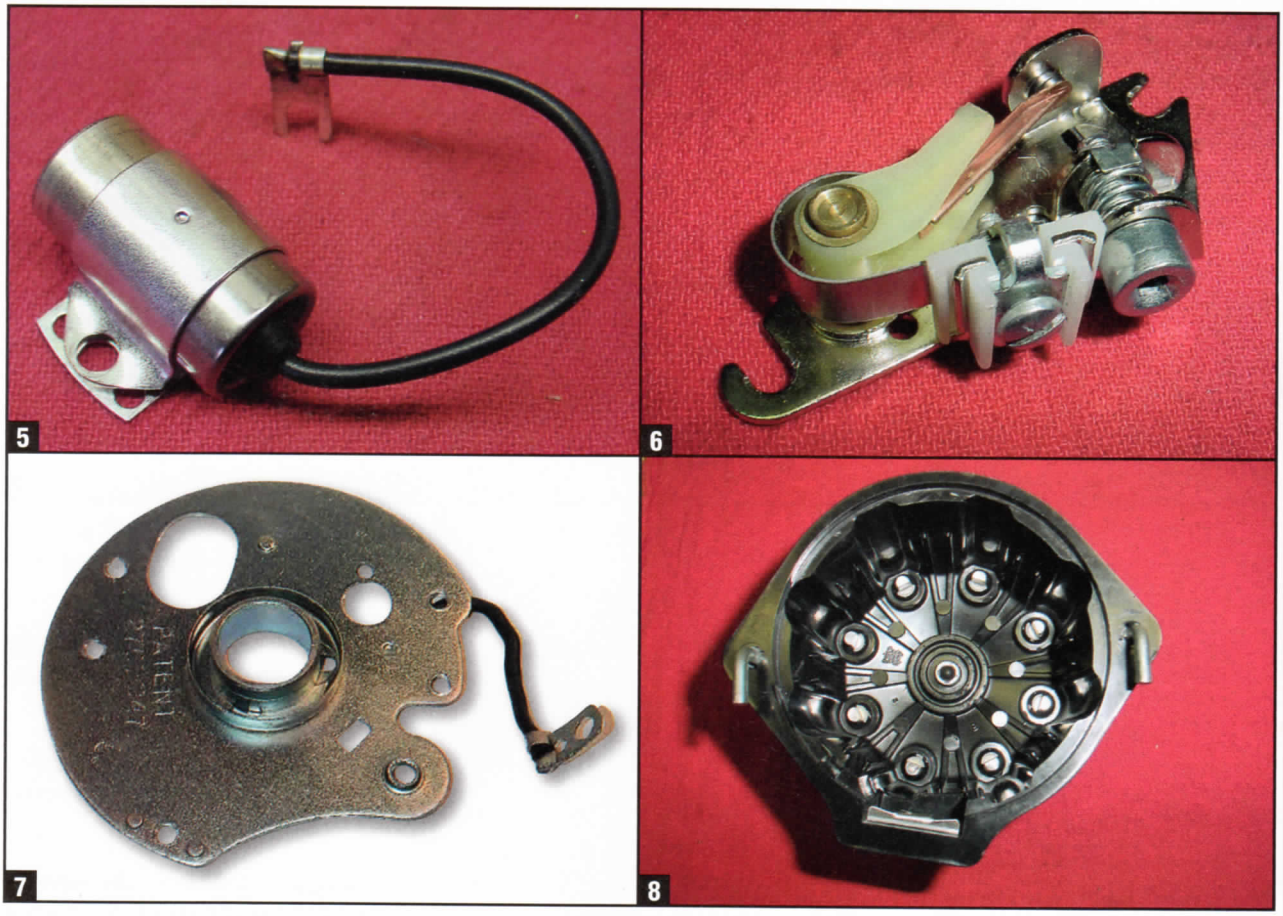
4 A typical ignition coil–this one is a direct replacement for most '55-'74 Corvettes, labeled for use with an external ballast resistor.

revolutionized the industry by inventing the self-starter. The Kettering ignition system used battery power to energize a coil as a step-up transformer, contact points to switch the current on and off, a capacitor to protect the points, and a distributor to send the high-voltage spark energy from the secondary side of the coil to the correct spark plug at the correct time. The Kettering ignition system was introduced on the 1910 Cadillac, along with the self-starter, and the same basic principles are still used today on every spark-ignition engine on the planet.

OVERVIEW: Here's a quick summary of the components of the ignition system and what they do–we'll discuss each one in detail later. **Battery**–provides a continuous supply of 12-volt electrical power to the system. **Ballast Resistor**–placed between the ignition switch and the coil to reduce the battery's 12 volts to 6-7 volts with the key in the "run" position. **Starter Solenoid**–bypasses the ballast resistor and supplies a full 12 volts from the battery to the coil during cranking for improved starting. **Coil**–serves as a step-up transformer, converting battery voltage to the 20,000 volts required to fire the spark plugs. **Points**–which switch the current on and off in the primary windings of the coil, creating the high-voltage spark energy sent to the distributor cap. **Condenser**–aids in the rapid collapse of the magnetic field in the coil, and extends point life by absorbing primary current spikes that would otherwise result in arcing and pitting the point contact surfaces. **Distributor Cap**–accepts the high-voltage spark energy from the coil, transfers it to the rotor, and distributes it from the rotor tip to the spark plugs. **Rotor**–accepts the high-voltage spark energy from the distributor cap and transfers it to the spark plug wire terminals in the cap. **Distributor**–operates the points, synchronizes spark timing to engine rpm, and contains the centrifugal and vacuum spark advance systems. **Centrifugal Advance System**–provides spark advance based on engine rpm. **Vacuum Advance System**–provides spark advance based on engine load.

HOW THE SYSTEM WORKS: When you turn the key on, current flows from the battery, through the ignition switch to the ballast resistor, to the (+) terminal on the coil, to the primary windings in the coil, which creates a strong magnetic field in the coil's soft iron core. When the points are closed, current continues to flow from the coil's primary windings through the wire on the (-) coil terminal to the points in the distributor to the ground, and back to the battery.

When the points open, the flow of



5 The condenser, which assists in the rapid collapse of the coil's magnetic field and minimizes arcing and pitting of the points.

6 The points are the switch for the coil primary windings, operated by the cam attached to the distributor mainshaft; their gap establishes the dwell, which determines coil saturation time.

7 The points mount on this breaker plate, which provides their ground wire; the vacuum advance diaphragm rotates it to alter spark timing based on engine load.

8 High-voltage current from the coil enters the distributor cap through the carbon contact button at the center, and exits through the spark plug wire tower terminals.

current through the coil primary windings is interrupted, causing the magnetic field to collapse. The collapsing magnetic field induces high voltage in the secondary windings in the coil, creating the high-voltage spark energy that exits the coil through the center terminal and is sent to the distributor cap. The condenser across the points aids in the rapid collapse of the magnetic field and prevents arcing across the point's gap.

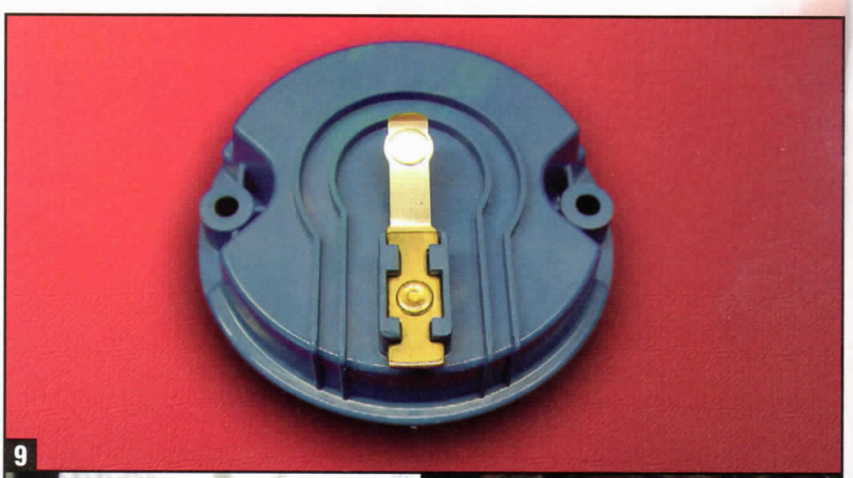
The rotor inside the cap distributes the high-voltage spark energy to the spark plug wire terminals, synchronized and timed by the distributor and its advance systems. All of this happens 200 times per second at highway speed.

HOW THE COMPONENTS WORK: The ballast resistor reduces the battery's 12 volts to 6-7 volts to the coil primary windings during normal operation to extend the life of the contact points and to prevent the coil from overheating. Corvettes used a separate firewall-mounted ceramic-encased resistor through 1967, which was replaced by a special cloth-covered resistance wire in the harness from 1968-1974. The nominal value of the resistor was 0.3 ohms until 1963, when it was replaced by a 1.8-ohm resistor to improve point life.

Besides engaging the starter, a set of contacts inside the solenoid feed a full 12 volts from the battery cable connection to its "R" terminal during cranking; a wire from that terminal connects directly to the coil's (+) terminal, bypassing the ballast resistor, so the coil's primary windings get a full 12 volts. This increased primary voltage creates a higher voltage in the coil's secondary windings, providing a hotter spark for improved starting. When the starter disengages, those internal contacts open, and the coil is again fed reduced voltage from the ballast resistor.

The coil is the heart of the ignition system, acting as a step-up transformer, to convert battery voltage to the 20,000 volts required to jump the gap at the spark plugs. The coil's primary windings consist of 100-150 turns of heavy copper wire, wound around a soft iron core. Current from the ignition switch enters the windings at the (+) terminal, and exits from the (-) terminal, through the points in the distributor, to the ground. The coil secondary windings consist of thousands of turns of fine copper wire, wound inside the primary windings, around the soft iron core, connected to the center high-voltage terminal in the cap. To withstand the heat of constant current flow, the coil is sealed and filled with oil to help cool it.

As current flows through the primary



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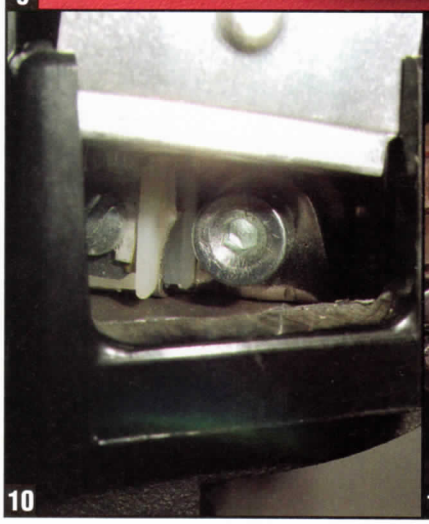

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9 The rotor attaches to the centrifugal advance mechanism, and transfers high-voltage current from the center of the cap to the plug wire terminals.

10 The "window" in the distributor cap allows access to the adjustment screw on the points for setting dwell with the engine running.

11 The centrifugal advance weights and springs at the top, and the vacuum advance connected to the breaker plate at the bottom; both systems operate independently, but complement each other.

windings, a strong magnetic field is created around the iron core. When the points open, that current flow is disrupted, and the magnetic field collapses rapidly. The collapse and movement of that magnetic field across the secondary windings induces a very high voltage, which is fed to the center terminal and from there to the distributor cap.

When the points open, and the magnetic field created by the primary windings in the coil begins to collapse, some primary current continues to flow. The condenser provides a place for that low-voltage current to go. Once the condenser is charged, the current flow through the primary is stopped instantly, and that rapid cutoff allows the magnetic field to collapse completely, inducing the high voltage in the coil's secondary windings. The absorption of that primary current by the condenser also avoids arcing across the points when they're opening, minimizing pitting of the point surfaces and extending point life.

The points are simply a switch, completing and opening the circuit between the coil's primary windings and ground. When the points are closed, current flows through the primary windings to the ground, creating the magnetic field in the coil. The period of time during which the points are closed is called "dwell," when the coil is being "saturated" with primary current. When the distributor cam opens the points, the primary circuit to the ground is opened, causing the magnetic field in the coil to collapse, which induces high voltage in the secondary windings.

Later electronic ignition systems (like the Corvette Transistor Ignition System and the GM HEI system introduced in 1975) and electronic conversions like the Pertronix, Breakerless SE, and

Crane XR-i systems utilize electronics to handle the switching function, but otherwise operate in the same manner as the classic points system. The latest distributorless ignition systems use a separate coil for each spark plug, switched electronically by signals from the engine control computer.

The distributor cap is molded from a high-dielectric (non-conductive) plastic material. The high-voltage current from the coil enters at the carbon center conductor, goes through the rotor, and exits across the small gap between the tip of the rotor and the terminals that feed each spark plug wire. The inside of the cap must be clean, dry, and free of any cracks or carbon tracking in order to ensure reliable operation, and the terminals at each spark plug wire tower must be clean and shiny for efficient transfer of high-voltage secondary current to the plug wires.

The rotor is also molded from a high-dielectric plastic, mounted to the centrifugal advance cam on top of the distributor mainshaft. The high-voltage current from the carbon center conductor in the cap flows into the spring contact on the rotor and flows out from the rotor tip across a small gap to each of the spark plug wire terminals. The spring end must have solid contact with the center conductor button in the cap, and the tip should be checked for erosion and damage from arcing.

The cam on the distributor mainshaft operates the points, and the breaker plate they're mounted on provides their ground. The distributor establishes and maintains initial spark timing so the high-voltage current is delivered to the spark plugs at the optimum time during the compression stroke. It also contains the centrifugal and vacuum advance systems.

Since the flame front in the combustion chamber travels at the same rate regardless of engine rpm, a system is required to alter the spark timing to fire the spark plugs earlier as rpm increases. A pair of spring-loaded flyweights connects the point cam to the top of the distributor mainshaft; the shape of the weights and the configuration of the plate on top of the mainshaft, together with a limiting pin and slot arrangement, determines the maximum amount of advance, and the tension of the springs retaining the weights determines when the advance begins and the rate at which the advance is increased. Advance is provided by advancing the point cam's position on

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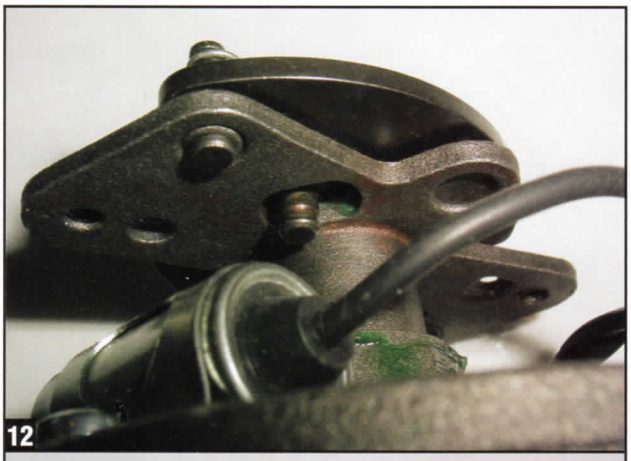
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12 The slot with the pin protruding through it determines the maximum advance the centrifugal system can provide.

13 The end of the rod on the vacuum advance diaphragm engages a hole in the breaker plate and advances spark timing based on engine load.

14 The dwell meter is an essential tool for setting the points, which determines coil saturation time; every Corvette owner should have one.

15 A good timing light is another essential tool for setting initial timing; this is a "dial-back" light, which permits easy checking and mapping of the centrifugal and vacuum advance systems as well.

the mainshaft, to open the points earlier, based solely on engine rpm.

Lean mixtures at idle and part-throttle steady-state cruise take longer to burn than rich mixtures under load and acceleration, so another system is required to alter spark timing based on engine load and throttle position. A diaphragm is connected to the movable breaker plate the points are mounted to and operated by intake manifold vacuum. When manifold vacuum is high at idle and steady-state cruise with a lean fuel mixture, the diaphragm pulls on the breaker plate, advancing the points relative to the cam that operates them so the spark is delivered earlier; when the throttle is opened to accelerate with a richer fuel mixture, manifold vacuum decreases, and the vacuum advance is reduced or drops out entirely, retarding spark timing back to the level provided by the distributor's initial timing setting and that provided at the time by the centrifugal advance system. The vacuum advance system responds based solely on engine load.

SUMMARY: Most of your Corvette's ignition system sits back there in the dark, hidden under the shielding, and doesn't get much attention unless it's tune-up time or when it fails. When you consider all the components involved and the speed at which it operates, its reliability is amazing, especially if you remember that it was invented by "Boss" Kettering in 1910 and its basic principles of operation haven't changed much since then. Hopefully this article will dispel some of the "mystery" of how it operates, and will be helpful in maintaining and diagnosing the system. ■