

Ignition Systems

Igor Porfirio Nº1020361

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Summary

On this presentation we will try to explain the importance and complexity, that the Ignition Circuit involved. The evolutions and reasons that provoke them will also be explore.

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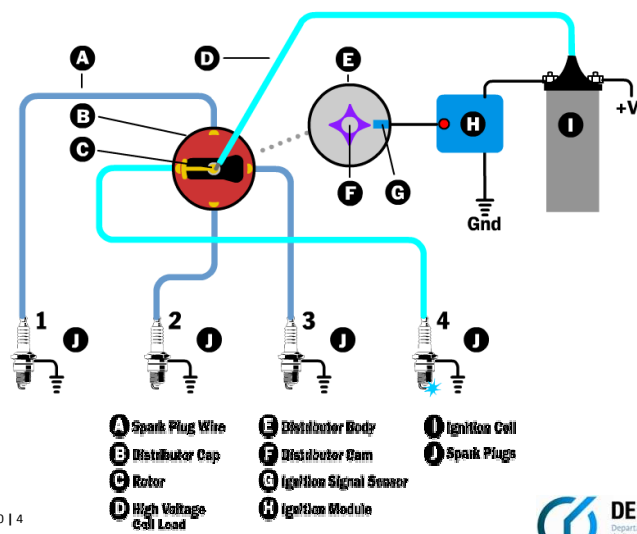
Introduction

How thus an ignition system work:



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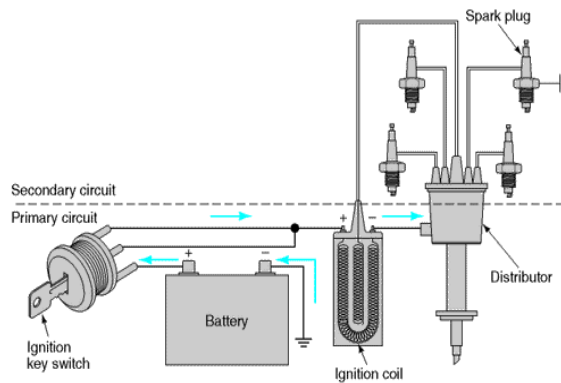
Introduction



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Introduction

As it was seen on the movie, the ignition circuit is actually made of two separate circuits which work together to cause the electric spark at the spark plugs. These two circuits are the PRIMARY and SECONDARY.



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Primary Circuit

The primary circuit of the ignition circuit includes all of the components and wiring operating on low voltage. Wiring in the primary circuit uses conventional wire, similar to the wire used in other electrical circuits on the vehicle.

The primary circuit consists of:

- Battery - provides the power to run the system.
- Ignition Switch - allows the driver to turn the system on and off.
- Breaker switch - a mechanical switch that acts as the triggering mechanism.
- Condenser - protects the points from burning out.
- Primary Coil - produces the magnetic field which creates the high voltage in the secondary coil.
- Wires - join all the components together.

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Secondary Circuit

The secondary circuit of the ignition circuit is the high voltage section. It consists of the wire and components between the coil output and the spark plug ground. Wiring in the secondary circuit must have a thicker insulation than that of the primary circuit to prevent leaking (arcing) of the high voltage.

The Secondary Circuit consists of:

- Secondary Coil - the part of the coil that creates the high voltage electricity.
- Coil Wire - a highly insulated wire, that takes the high voltage from the coil, to the distributor cap.
- Distributor Cap - a plastic cap which goes on top of the distributor, to hold the high tension wires in the right order.
- Rotor - spins around on the top of the distributor shaft, and distributes the spark to the right spark plug.
- Spark Plug Wires - another highly insulated wire that takes the high voltage from the cap to the plugs.
- Spark Plugs - take the electricity from the wires, and give it an air gap in the combustion chamber to jump across, to light the mixture.

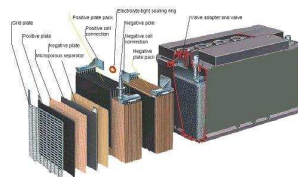
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Basic Components to a Ignition System

Various ignition circuit components are designed to achieve the specific functions on the ignition system. That components are:

- BATTERY- provides power for the circuit. (This was discussed earlier in this chapter.)



- IGNITION SWITCH- allows the operator to turn the circuit and engine ON and OFF.

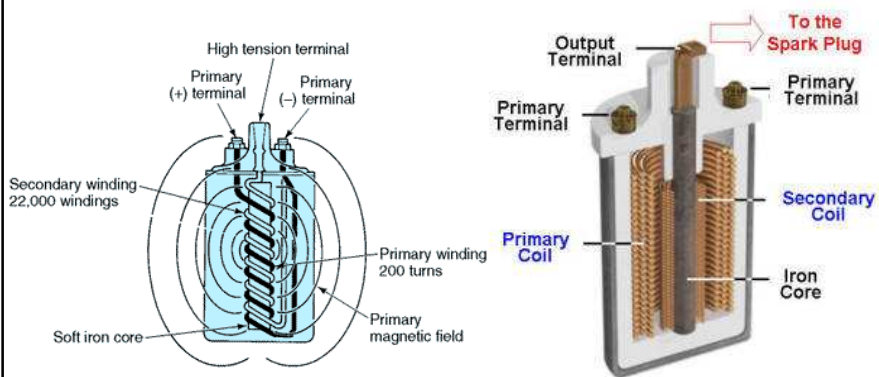


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Basic Components to a Ignition System

- **IGNITION COIL-** changes battery voltage to high ignition voltage (30,000 volts and greater).

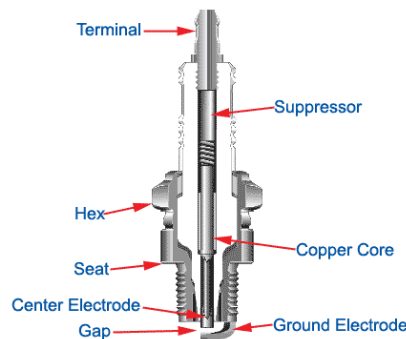


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Basic Components to a Ignition System

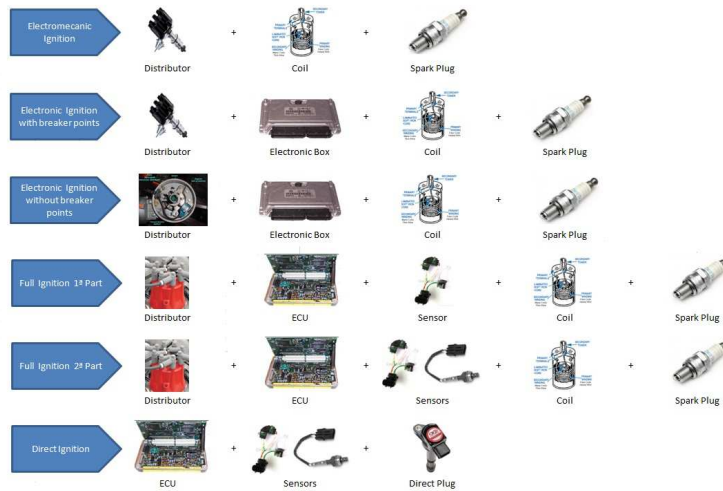
- **IGNITION DISTRIBUTOR-** distributes ignition voltage to the spark plug. Contains either mechanical contact points or an electronic switching circuit.
- **SPARK PLUG-** device that provides an air gap in the combustion chamber for an electric arc.



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Different transformations on the Ignition System



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Turning Points on the Development

There are three major breakthrough on the ignition systems development, that happen in different points of history:

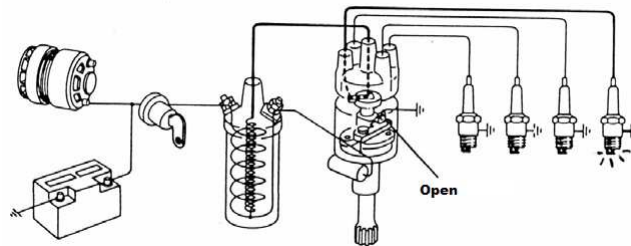
- Breaker Ignition
- Electronic Ignition
- Direct Ignition

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Breaking Ignition

With the engine running, the distributor shaft and distributor cam rotate. This action causes the distributor cam to open and close the contact points.

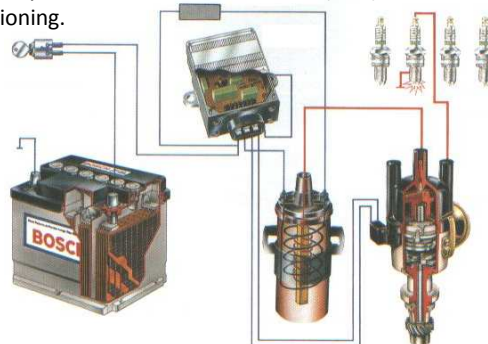
With the contact points wired to the primary windings of the ignition coil, the contact points make and break the ignition coil primary circuit. With the contact points closed, the magnetic field builds up in the coil. As the points open, the magnetic field collapses and voltage is sent to the spark plugs.



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Electronic Ignition System

The basic difference between the contact point and the electronic ignition system is in the primary circuit. The primary circuit in a contact point ignition system is open and closed by contact points. In the electronic system, the primary circuit is open and closed by the electronic control unit (ECU), that uses sensors to identify the cycle positioning.



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The causes that lead to the Electronic Ignition

Disadvantages of the Breaker Ignition system facing the Electronic Ignition:

- Longevity of the ignition points
- The maximum amount of current that can flow through the ignition points, was limited to values around 4 amps.
- This control directly affects the maximum secondary voltage output of the ignition coil by reducing the amount of coil saturation.
- Another drawback is the limitations placed on the system at high engine speeds.
- Breaker point ignition systems require frequent maintenance to ensure the correct operation of the ignition system .
- The voltage required to ignite a lean air/fuel mixture could not be economically provided by the breaker point system.

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Direct Ignition System

The most common arrangement in modern engines is an ignition coil mounted on top of each cylinder, right on top of the spark plug, eliminating the need of spark plug wires, since the spark plug boot is connected directly to the ignition coil. In either set-up, the timing is controlled directly by the engine control computer, either advancing it as it needs to or retarding it if necessary.



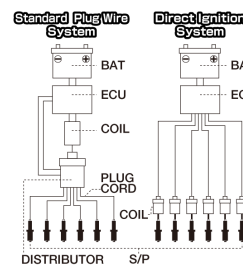
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The causes that lead to the Direct Ignition

In case of a Plug Wire System, the voltage is increased by one coil pack and sent to respective spark plug through distributor and individual plug wires, and therefore, the voltage will be decreased at each process before the electricity reaches to spark plug. But, in case of Direct Ignition Systems, each coil directly sends an increased voltage to spark plug without any loss of electricity. Moreover, the best ignition timing is gained by computer and is controlled by ECU along with fuel injection system. The strong point of Direct Ignition System is to provide an accurate ignition and to maintain stable secondary voltage at high RPM.

Comparative Illustration between Plug Wire System and Direct Ignition System



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Sequence of Steps During the Transformation

- Prior to the early 70's, breaker point ignition systems were used on all vehicles.
- Until the 80's the electronic ignition system allowed automotive engineers to re-design the ignition system components to generate higher secondary ignition voltage..
- Most late model automobiles now use distributorless ignition systems. The distributorless ignition system provides higher secondary voltages, more efficient operation and lower maintenance, in comparison with conventional electronic ignition systems.

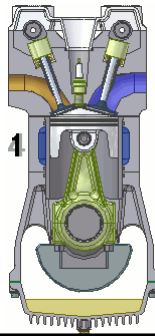
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Ignition System Functions

The Ignition System has three major functions that should be performed:

- Generate a spark, capable of bridging the gap of the spark plug in the harsh environment of the combustion chamber and ignite the mixture.
- The spark needs to have the proper duration to allow all the compressed gases to burn.
- The spark should be delivered on the right moment to maximize the power and minimize the emissions.



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Ignition timing

To give the maximum cylinder pressure and therefore the maximum horsepower, burning of the gases must be finished by shortly after Top Dead Center. If the piston is allowed to go too far down the cylinder, the combustion chamber volume will have become too big, the pressure will drop and so will the power and economy.

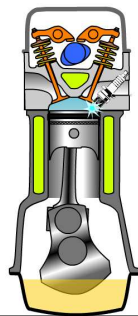


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Spark Advance Angle Control

The basic methods to control ignition system timing are as follows:

- CENTRIFUGAL ADVANCE (controlled by engine speed)
- VACUUM ADVANCE (controlled by intake manifold vacuum and engine load)
- COMPUTERIZED ADVANCE (controlled by various sensors- speed, temperature, intake, vacuum, throttle position, etc.)



- 1 INTAKE
- 2 COMPRESSION
- 3 COMBUSTION
- 4 EXHAUST
- ▲ Spark
- Top Dead Center

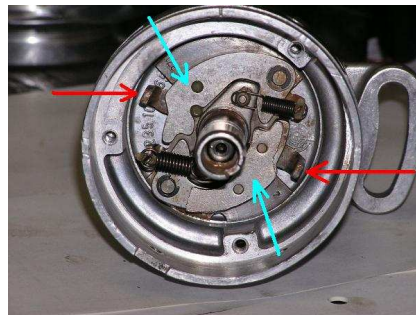
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Centrifugal Advance

The Centrifugal advance mechanism controls ignition timing in relation to engine speed. It is located within the distributor, below the contact points' base plate and operates on the distributor shaft.

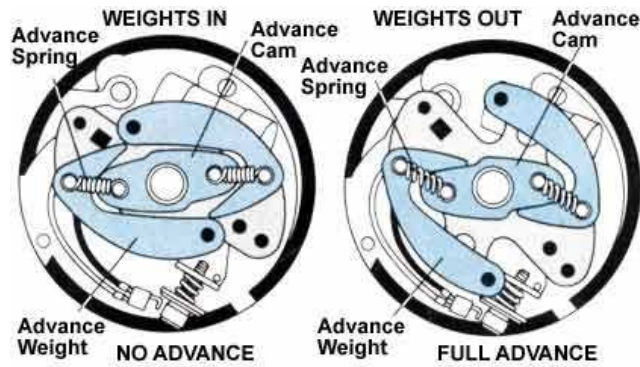
The lower shaft has two flyweights attached, each pivoted at opposite ends and controlled by a spring. As the shaft is turned they are thrown out by the effect of centrifugal force. The faster the shaft turns the more they move out. Slowing the turning speed reduces the amount of centrifugal force, so spring force pulls them in.



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Centrifugal Advance Positions



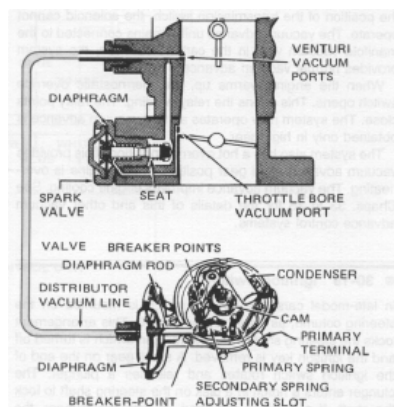
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Vacuum Advance

The vacuum advance mechanism controls ignition advance in relation to engine load.

Vacuum is ported from the carburetor to a spring-loaded diaphragm housing attached to the distributor. The movement results in the contact points' opening time being advanced according to engine load.

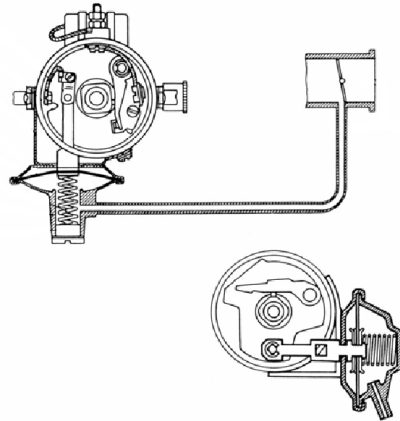


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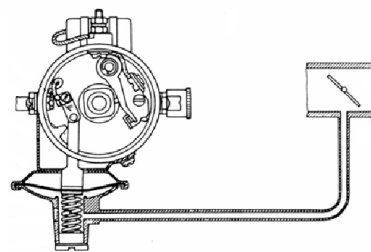


Vacuum Advance Positions

No Advance



Full Advance



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Spark Advance Angle Control

The computerized advance, also known as an electronic spark advance system, uses various engine sensors and a computer to control ignition timing. The engine sensors check various operating conditions and sends electrical data to the computer. The computer will change the ignition timing for maximum engine efficiency.

Ignition system engine sensors include the following:

- ENGINE SPEED SENSOR (reports engine speed to the computer)
- CRANKSHAFT POSITION SENSOR (reports piston position)
- THROTTLE POSITION SWITCH (notes the position of the throttle)
- INLET AIR TEMPERATURE SENSOR (checks the temperature of the air entering the engine)
- ENGINE COOLANT TEMPERATURE SENSOR (measures the operating temperature of the engine)
- DETONATION SENSOR (allows the computer to retard timing when the engine knocks or pings)
- INTAKE VACUUM SENSOR (measures engine vacuum, an indicator of load)

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Conclusions

After developing a profound investigation regarding the development of the Ignition System, we realised that the principle of the combustion engine had evolve significantly since its prier origins, but is efficiency is still to low, despite all the new technology apply to maximize is performance, regarding an electrical engine.