* NEED OF IGNITION SYSTEM :-

→ The ignition system has 3 main functions

1) It must generate an electrical spark with enough heat to ignite the air/fuel mixture in the combustion chamber.
2) It must maintain the spark long enough to allow for the combustion of all the air and fuel in the cylinders.
3) It must deliver the spark to each cylinder so that combustion can begin at the right time during the compression stroke of each cylinder.

* BATTERY IGNITION SYSTEM :-

It is based on the principale of mutual electromagnetic induction.

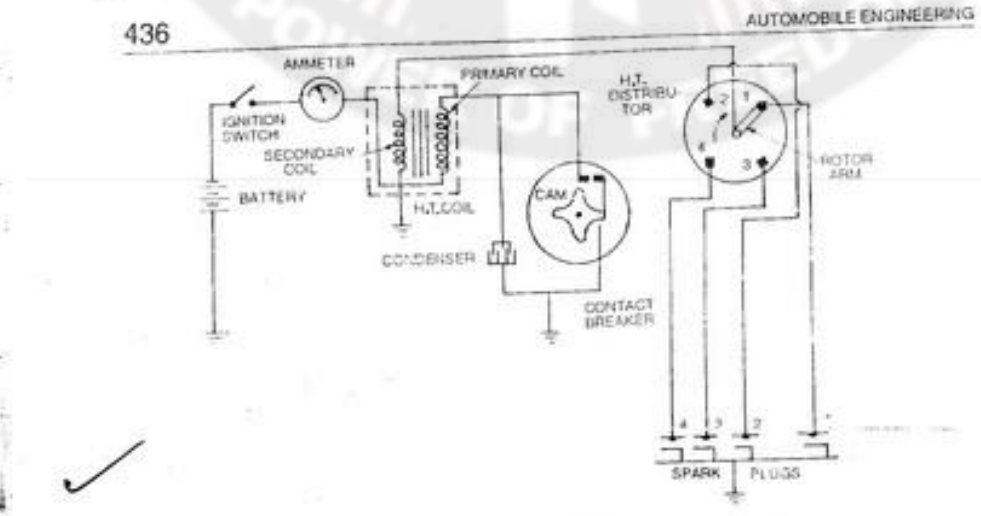


Fig shows a battery ignition system for a 4-cylinder engine. It consists of a battery, ammeter, switch, ignition coil, condenser, contact breaker, distributor and spark plug.

The primary ignition circuit includes:-

- battery
  ignition switch
  ammeter
  primary winding
  contact breaker pts to the ground.

The secondary ignition circuit includes:-

- secondary winding
  distributor
  spark plug to ground.

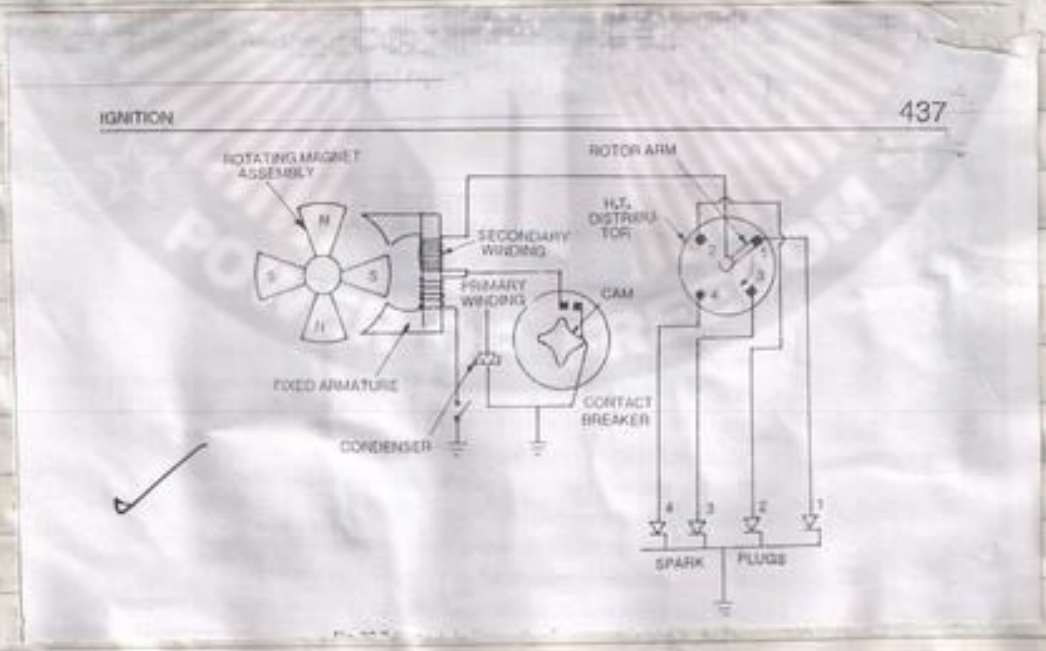
→ When the ignition switch is on, the current will flow from the battery thro the primary winding. It produces magnetic field in the coil. Further this current is grounded if the contact points are closed.

When the contact points open, the magnetic field collapses and the movement of the magnetic field induces current in the secondary winding coil. Because the secondary winding has many more turns (about 21,000 turns) of fine wire (40 SWG), the voltage increases upto 40,000 volts. The primary winding contains 200-300 turns of thick wire (20 SWG).

This increased voltage passes through the high tension lead to the distributor rotor. The rotor of the distributor revolves and distributes the current to the respective spark plugs depending upon the firing order.

* MAGNETO IGNITION SYSTEM :-

Fig shows a magneto ignition system for a four cylinder engine. It consists of a magneto, instead of a battery, which produces and supplies current in the primary winding. The remaining arrangement in this system is the same as that in the battery ignition system.



COMPARISON OF :-

Battery Ignition Sys.	Magneto Ignition Sys.
1) Battery is necessary. Difficult to start the engine when battery is discharged.	1) No battery is needed & therefore there is no problem of battery discharge.
2) Maintenance problems are more due to battery	2) Maintenance problems are less since there is no battery.
3) Current for the primary circuit is obtained from the battery.	3) The required electric current is generated by the magneto.
4) A good spark is available at the spark plug even at low speed.	4) During starting, quality of spark is poor due to low speed.
5) Efficiency of the system decreases with the reduction in spark intensity as engine speed rises.	5) Efficiency of the system improves as the engine speed rises due to high intensity spark.
6) Occupies more space	6) Occupies less space.
7) Commonly employed in cars and light commercial vehicles	7) Mainly used in racing cars and two wheelers

* COMPONENTS OF IGNITION SYSTEM :-

(I) IGNITION COIL :-

The purpose of the ignition coil is to step up the 6 or 12 volts of the battery to a high voltage, sufficient to induce an electric spark across the electrodes of the spark plug.

TYPES OF IGNITION COILS :-

The ignition coils may be of two types:

(a) Core type ignition coil :-

In this type of coil, the primary winding is wound around the iron core forming double 'C' with air gap.

The secondary winding is wound outside the primary winding.

The core is of a rectangular cross-section and is made of soft iron lamination

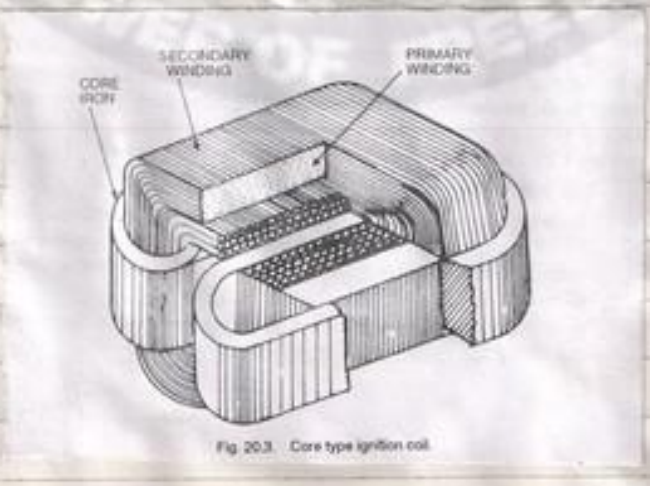


Fig. 20.3. Core type ignition coil

(b) Can Type Ignition Coil :-

Const→ - In this type of coil, the secondary winding which consists of about 21000 turns of 38-40 gauge enamelled copper wire is wound around the core.

- The primary winding which consists of about 200-300 turns of 20 gauge wire is wound over the secondary winding.

- The entire core assembly is placed in a steel casing which is fitted with a cap of moulded insulating materials.

- The windings are immersed in oil to improve insulation and to reduce moisture effect.

Working :-

→ When the ignition switch is turned on, the current flows from the battery thro the primary winding.

→ When the contact breaker points open, the primary circuit breaks & the magnetic field collapses.

→ Rapid collapsing of magnetic field induces high voltage in both the primary & secondary winding.

→ The current flowing in the primary winding, runs towards the contact breaker points and the circuit is completed thro ground.

→ The high voltage current flowing thro the secondary winding goes to the distributor

from where it is distributed to the proper spark plug thro the high tension lead.

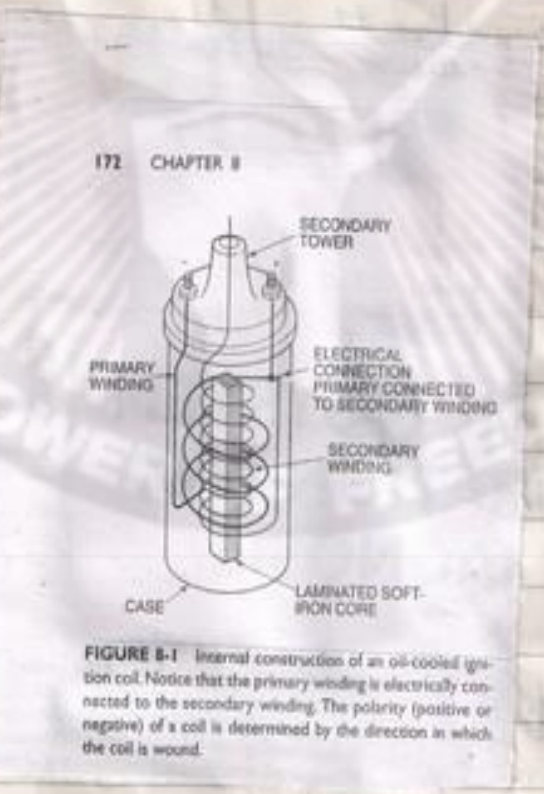


FIGURE 8-1 Internal construction of an oil-cooled ignition coil. Notice that the primary winding is electrically connected to the secondary winding. The polarity (positive or negative) of a coil is determined by the direction in which the coil is wound.

(II) DISTRIBUTOR:-

The distributor consists of a distributor housing, contact breaker, rotating shaft with a breaker cam, condenser, rotor cap and an ignition advance mechanism to vary ignition timing in accordance with the engine load and speed.

→ The two main functions of the distributor are :-

a) To interrupt the flow of current through the primary winding so that a high voltage is produced in the secondary winding.
b) To distribute the high voltage surge to different plugs at the right moment.

(III) CONTACT BREAKER:-

This is a mechanical device for making and breaking the primary circuit of the ignition coil.

It consists of a fixed metal point against which, another metal point bears which is being on a spring loaded pivot arm.

The metal used is invariably one of the hardest metals, usually tungsten & each point has a circular flat face of about 3 mm diameter

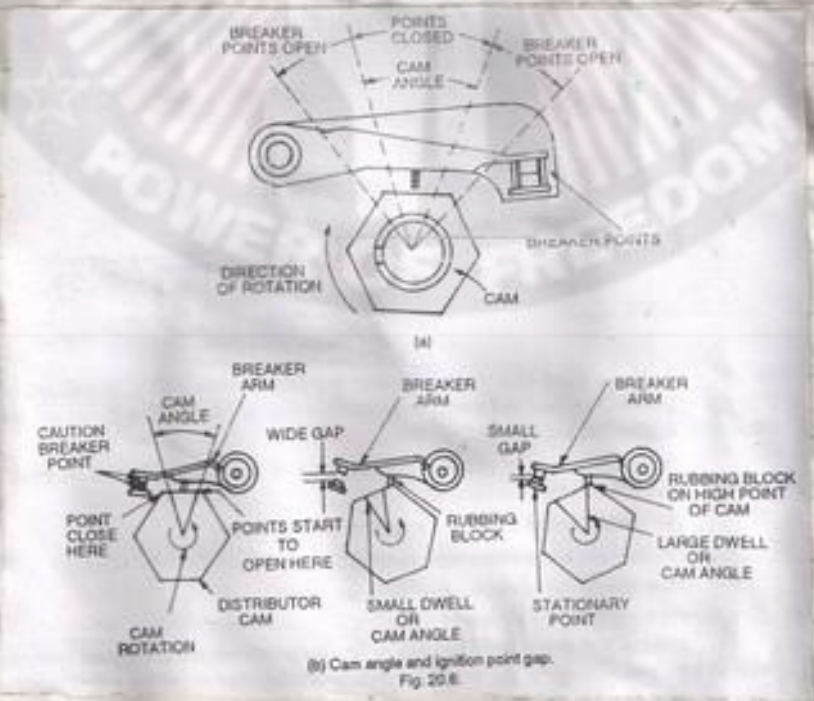
The fixed contact point is earthed & the arm to which the movable

contact point is attached, is electrically ~~separated~~ insulated.

→ When the points are closed the current flows and when they are open, the circuit is broken and the flow of current stops.

→ The gap between the points is generally of the order of 0·35 mm to 0·55 mm. The angle between the cam lobes depends upon the number of engine cylinders.

→ An eight cylinder engine running at 3000 rpm requires 12000 sparks per minute i.e. 200 sparks per second.



(b) Cam angle and ignition point gap.
Fig. 20.6

(IV) SPARK PLUG :-

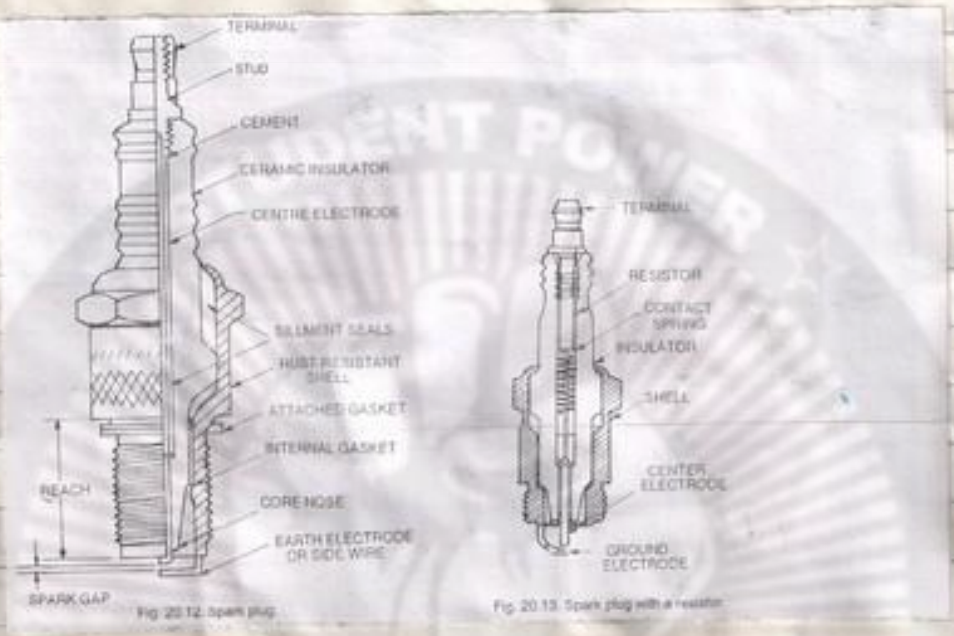


Fig. 20.12. Spark plug

Fig. 20.13. Spark plug with a resistor

→ A spark plug consists of a steel shell, an insulator and two electrodes viz centre electrode or insulated electrode (ground electrode or outer electrode.

→ The upper end of the centre electrode is connected to the spark plug terminal, where high tension (H.T.) cable from the ignition coil is connected. It is surrounded by porcelain insulator.

→ The lower half portion of the insulator is fastened with a metal shell. The lower portion of the shell has a short electrode attached to one side and bent in towards the centre

electrode, so that there is a gap between the two electrodes.

The electrodes are usually made of high nickel alloy to withstand the severe erosion and corrosion to which they are subjected in use.

TYPES OF SPARK PLUGS :-

Spark plugs are usually classified as
a) hot plugs or
b) cold plugs.

The types depend upon the relative operating temperature range of the tip of the high tension electrode.

The operating temperature is governed by the amount of heat transferred which in turn depends on the length of the heat transfer path from the tip to the cylinder head.

→ A cold plug has a short heat transfer path and a small area exposed to the combustion gases as compared to a hot plug as shown in fig.

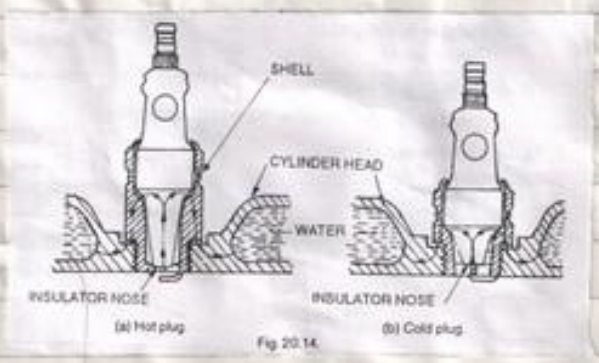


Fig. 20.14.

(V) SPARK PLUG CHORDS:- (IGNITION CABLES)

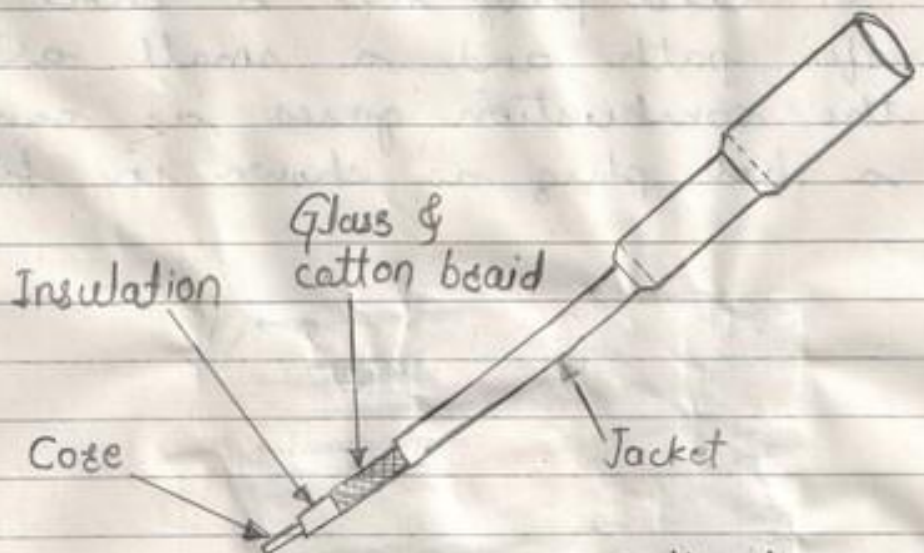
→ Ignition cables (spark plug chords) carry the high voltage from the distributor or the multiple coils (EI system) to the spark plugs.

→ The cables are not solid wire, but they contain carbon-impregnated fibre cores which act as resistors.

→ The resistance reduces radio and television interference, increases firing voltages and reduces spark plug wear by decreasing current.

→ Metal terminals on each end of the spark plug wires contact the spark plug and the distributor cap terminals.

→ Insulated boots on the ends of the cables strengthen the connections as well as prevent dust and water infiltration and voltage loss.



- Hypalon - Normal
- Silicon - High temp.

(VI) CONDENSER :-

→ Fig shows an assembled & partly unwound condenser

→ It contains two plates electrically insulated from each other

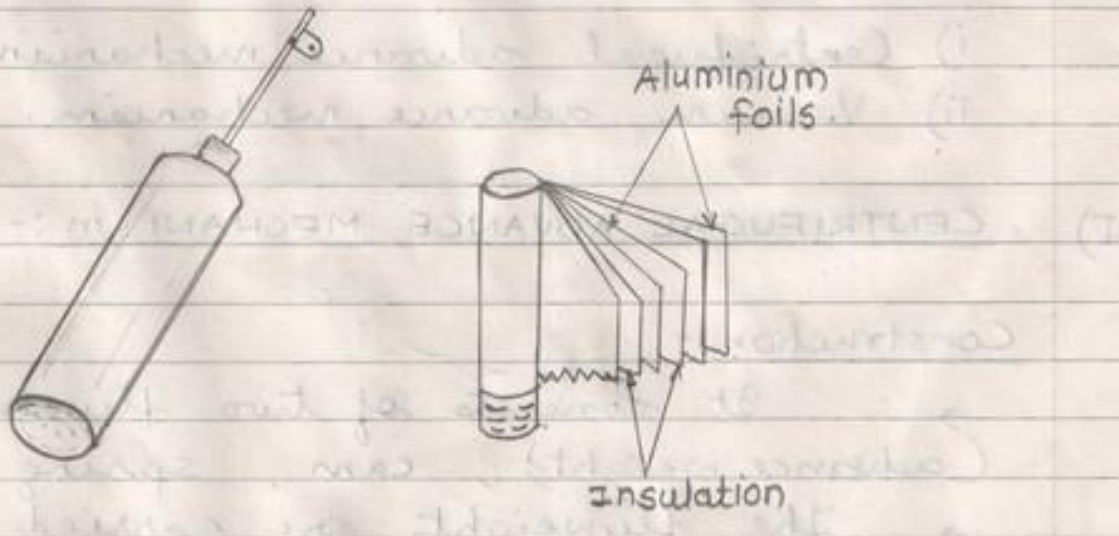
→ In case of an automotive ignition condenser, the plates are made up of two long thin strips of aluminium or lead foil.

→ A special condenser paper is used to insulate them from each other.

→ The condenser insulation resistance should be high e.g. 10 megaohms, & it should be capable of withstanding 1000V.

→ The capacitance should be between 0.15 and 0.35 microfarads. The general value is 0.20 - 0.25 microfarads.

→ The condenser is used to prevent the arc action in case of ignition system with distributor contact points.



Assembled & partly unwound condenser.

* ADVANCE & RETARD TIMING MECHANISM :-

IGNITION TIMING :-

Ignition timing refers to the precise time a spark is sent to the cylinder relative to the piston position.

→ Some of the important engine parameters affecting the ignition timing are :-

a) Engine speed
b) Engine load
c) mixture strength
d) Type of fuel.

→ Most of the engines are fitted with mechanisms which are integral with the distributor and automatically regulate the optimum spark advance to account for change of speed and load. The two mechanisms used are :-

i) Centrifugal advance mechanism
ii) Vacuum advance mechanism.

I) CENTRIFUGAL ADVANCE MECHANISM :-

Construction :-

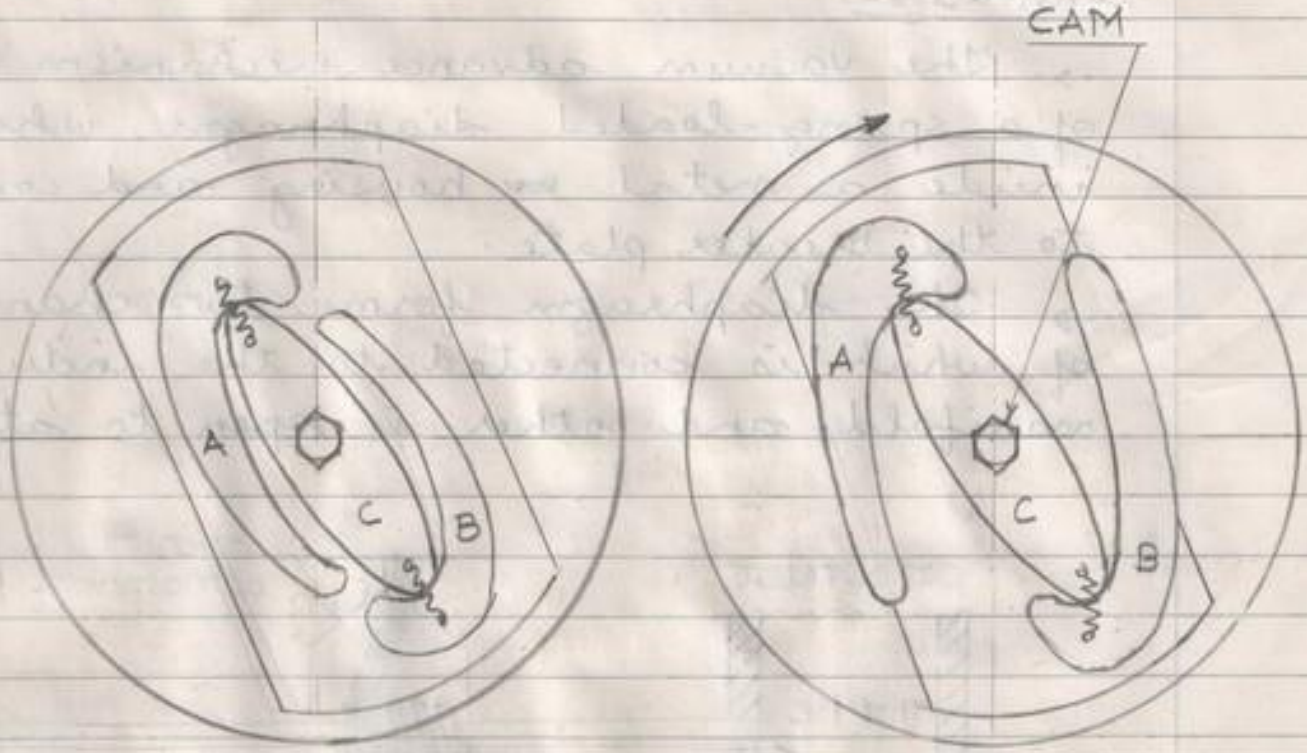
→ It consists of two flyweights (advance weight), cam, spring & base plate.

→ The flyweights are carried by the distributor drive shaft through the base

plate which is fixed to the drive shaft.

→ The flyweights are pivoted on the base plate and attached to the cam through springs

→ The cam is connected with the distributor drive shaft through the springs, flyweights, and base plate.



(a) (b)

Centrifugal advance mechanism

a) No advance b) Full advance

Working :-

→ When engine speed increases, the weights move outwards due to the centrifugal force, rotating the plate and cam in the anticlockwise direction.

→ This movement affects the desired advance.

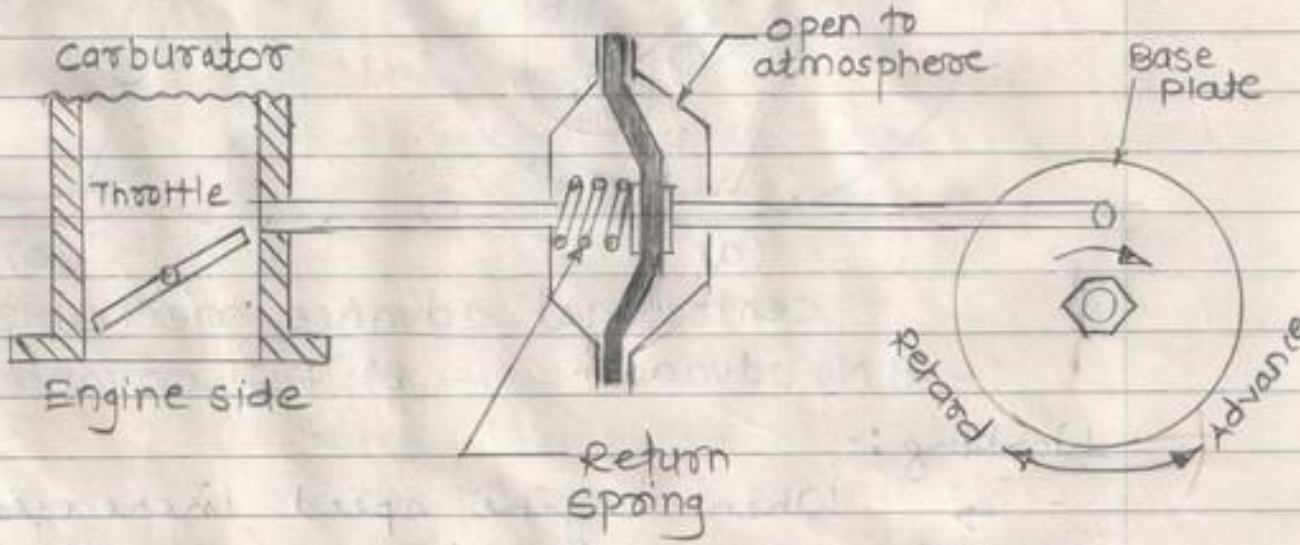
→ This timing of spark varies from no advance at low speed to full advance at high speed.

II) VACUUM ADVANCE MECHANISM :-

Construction :-

→ The vacuum advance mechanism consists of a spring-loaded diaphragm, which fits inside a metal housing and connects to the breaker plate.

→ The diaphragm forms two chambers, one of which is connected to the induction manifold and other is open to atmosphere.



Vacuum Advance mechanism

Working :-

→ When the engine load increases, induction manifold or vacuum pressure increases.

→ Any increase in vacuum allows the atmospheric pressure to push the diaphragm compressing the spring.

→ This movement of the diaphragm causes the breaker plate to rotate in the opposite direction of distributor rotation to advance the timing.

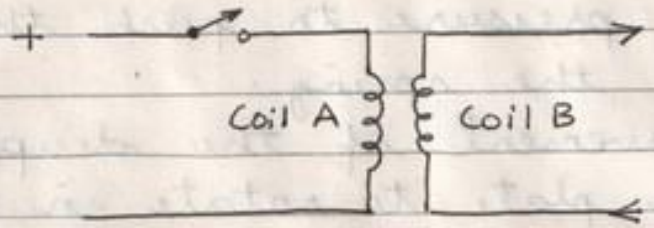
→ The rotation of the breaker plate moves the location of the breaker points so they open earlier.

→ When vacuum pressure decreases the diaphragm returns back due to spring tension (force) to retard the timing.

→ Hence the diaphragm advances & retards the ignition timing according to the engine load conditions.

* TRIGGERING OF PRIMARY CIRCUIT :-

A) MUTUAL INDUCTION :-



(Mutual induction can create a current in coil B if the current flow through coil A is switched on and off)

→ In an ignition coil there are two windings, a primary & a secondary winding.
→ Whenever there is a change in the magnetic field of one coil winding, there is a change in the other coil winding.
→ Therefore if current is stopped from flowing (circuit is opened), the collapsing magnetic field cuts across the turns of the secondary winding and creates a high voltage in the secondary winding.
→ The collapsing magnetic field also creates a voltage of up to 250 Volts in the primary winding.
→ This generation of an electric current in both coil windings is called "mutual induction".

B) INDUCTIVE (PULSE GENERATOR OR PICK-UP COIL) :-

→ The inductive triggering mechanisms consists of two parts namely :-
a) Stationary pick-up coil
b) Rotating trigger wheel (reluctor)

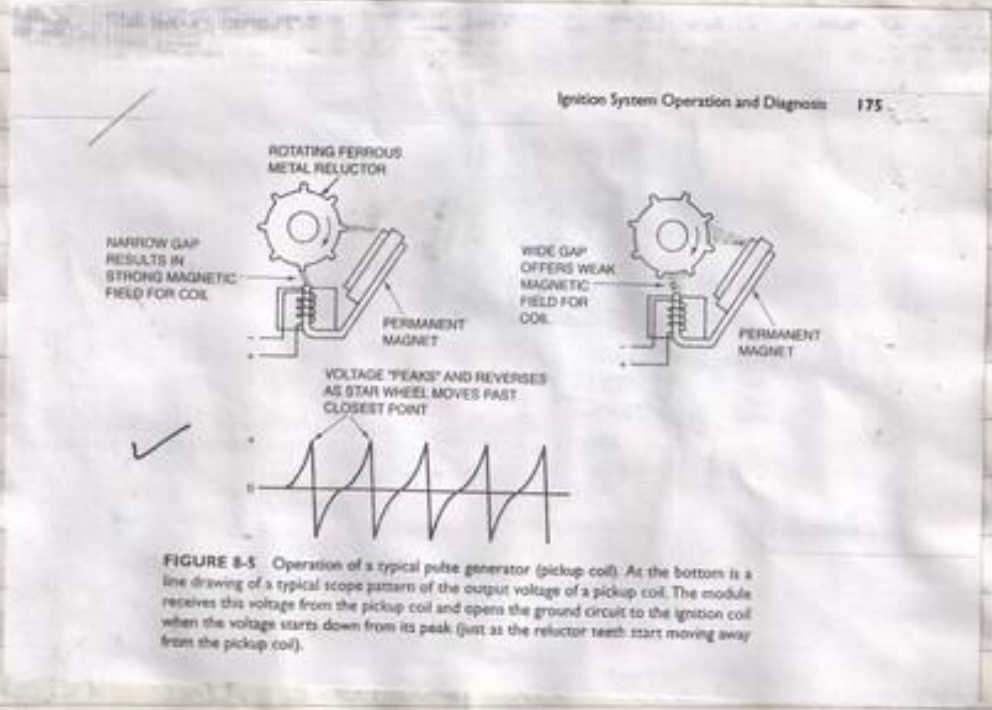


FIGURE 8-5 Operation of a typical pulse generator (pickup coil). At the bottom is a line drawing of a typical scope pattern of the output voltage of a pickup coil. The module receives this voltage from the pickup coil and opens the ground circuit to the ignition coil when the voltage starts down from its peak (just as the reluctor teeth start moving away from the pickup coil).

→ The pick-up coil consists of a length of wire wound around a weak permanent magnet
→ The reluctor (timing disc) may be mounted on the distributor shaft.
→ The magnetic pulse generator works on the principle of electromagnetic induction
→ The magnetic field is provided by the pick-up unit & the rotating timing disc provides the movement for the magnetic

field required to induce the voltage

→ When the tip of the rotating ferrous metal reluctor tooth comes directly inline with the pick-up coil, there is a narrow air gap being created between the two which results in a strong magnetic field, allowing the primary coil current to flow across the emitter-base circuit through the magnetic pick-up to ground.

→ When the reluctor tooth passes the centre of the magnetic pick-up there is a wide air gap being created which results in a weak magnetic field, which reverses the induced voltage and turn off the base of the switching transistor. This in turn switches off the primary ignition coil current.

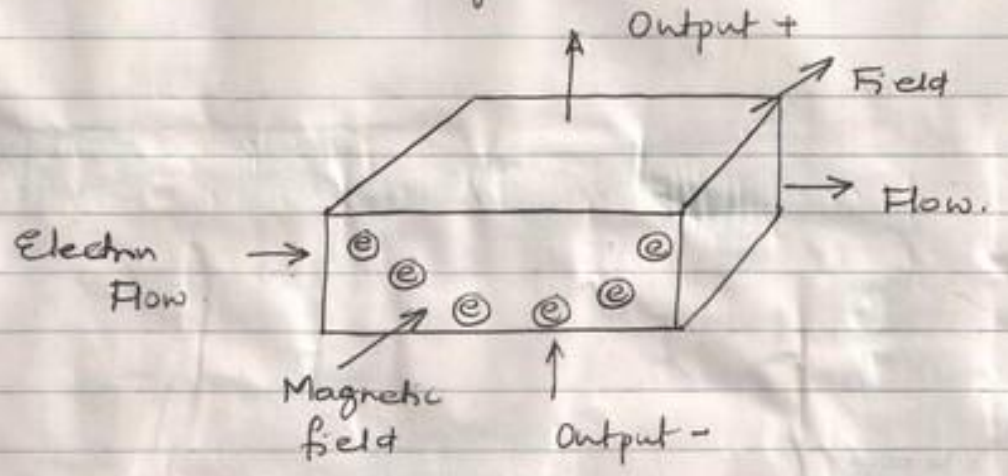
→ The very rapid cutoff of primary current collapses the magnetic field in the ignition coil to produce the high secondary voltage required to fire the spark plug.

c) HALL EFFECT SWITCH :-

→ The Hall effect was discovered by Edwin H. Hall in 1879.

→ He found that when a thin rectangular gold conductor, carrying a current, was crossed at right angles by a magnetic field, a difference of potential was produced at the edges of the gold conductor

→ Modern Hall-effect units use semiconductor material (usually silicon)



(Hall Effect Principle)

Working :-

→ The Hall effect switch consists of a Hall unit (silicon), a permanent magnet, and a rotating shutter wheel.

→ Whenever the opening of the rotating shutter wheel come in between the hall unit (sensor) & the permanent magnet, it allows the magnetic field to strike the sensor, and a small voltage is

produced and is sent to the electronic control unit.

→ As the distributor rotates, a blocking shutter blocks the magnetic fidd & the current stops flowing from the sensor.

→ The electronic control unit can be designed to either turn on or turn off the ignition coil primary current when the shutter blades (vanes) are blocking.

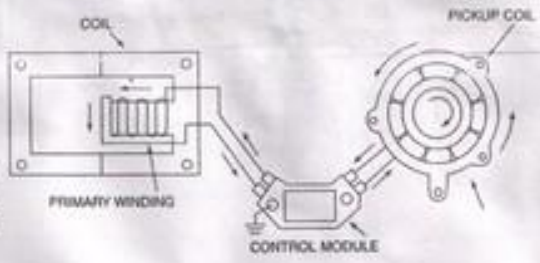


FIGURE 8-6 The varying voltage signal from the pickup coil triggers the ignition module. The ignition module grounds and ungrounds the primary winding of the ignition coil, creating a high-voltage spark.

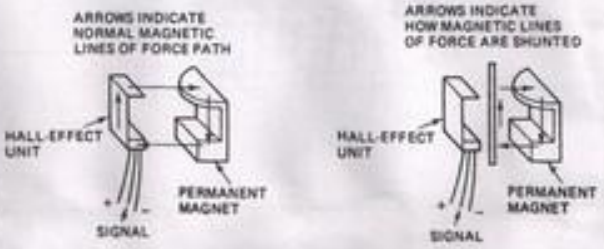
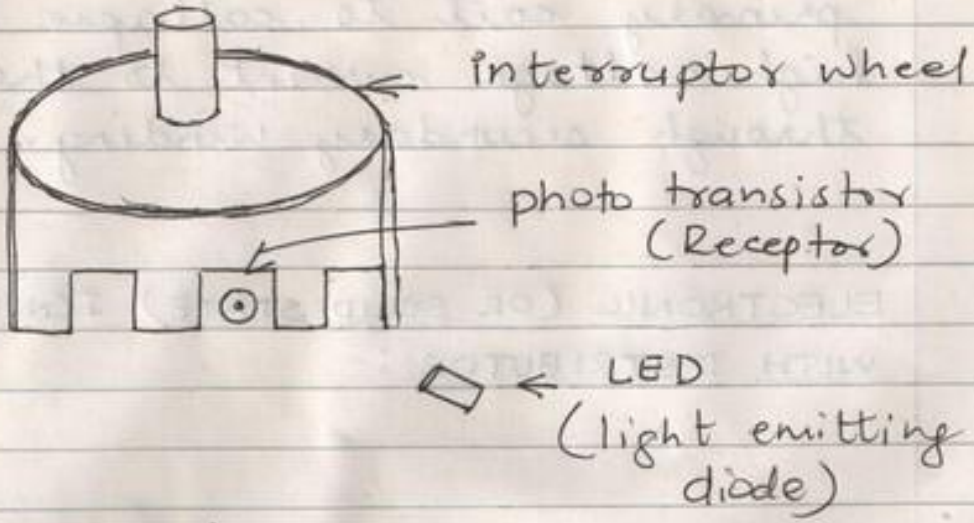


FIGURE 8-7 Hall-effect switches use metallic shutters to shunt magnetic lines of force away from a silicon chip and related circuits. All Hall-effect switches produce a square wave output for every accurate triggering.

D) OPTICAL METHOD :- (PHOTO ELECTRIC SENSOR) :-



→ An optical triggering mechanism consists of a light emitting diode (LED) and a light sensitive photo transistor (photocell) and also a slotted disc called a light beam interruptor

→ The slotted disc is attached to the distributor shaft

→ The LED & photocell are situated over & under the slotted disc opposite of each other

→ As the slotted disc rotates between the LED & the photocell, light from LED shines through the slots.

→ The intermitant flashes of the LED are translated into voltage pulses by the photocell.

→ Where the voltage signal occures, the control unit turns 'ON' the primary circuit.

→ When the disc interupts the light & the voltage signal is not given, the

control system turns the primary circuit 'OFF'. causing the magnetic field in the primary coil to collapse and sending a high voltage current to the spark plug through secondary winding.

* **ELECTRONIC (OR SOLID STATE) IGNITION SYSTEM WITH DISTRIBUTOR :-**

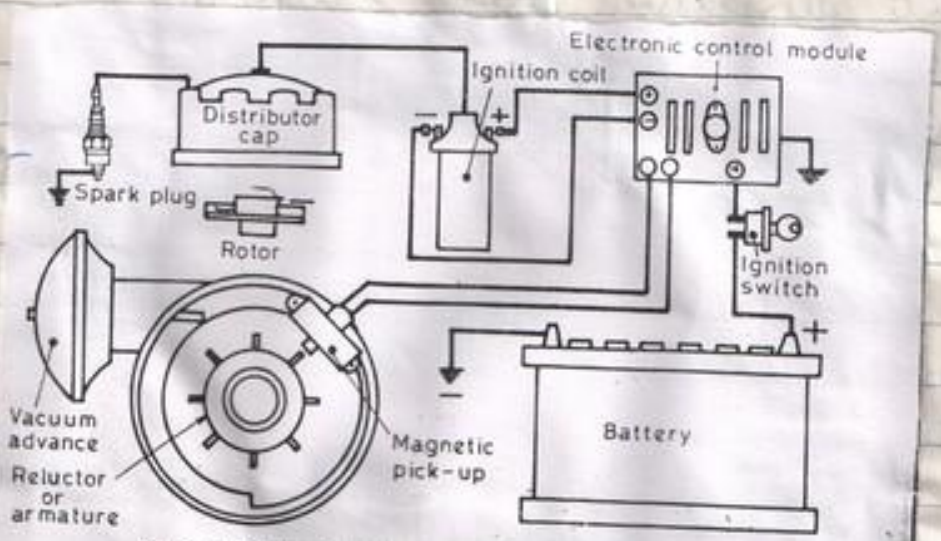


Fig. 13.22. Electronic ignition system using a magnetic pick-up.

→ Fig shows an electronic ignition system usin a magnetic pick-up.

→ The distributor of this system is similar to a conventional distributor except that the contact points have been replaced by a magnetic pick-up and cam has been replaced by a rotor or impluse reluctor.

→ The number of metal tips on the reluctor are equal to the number of engine cylinders.

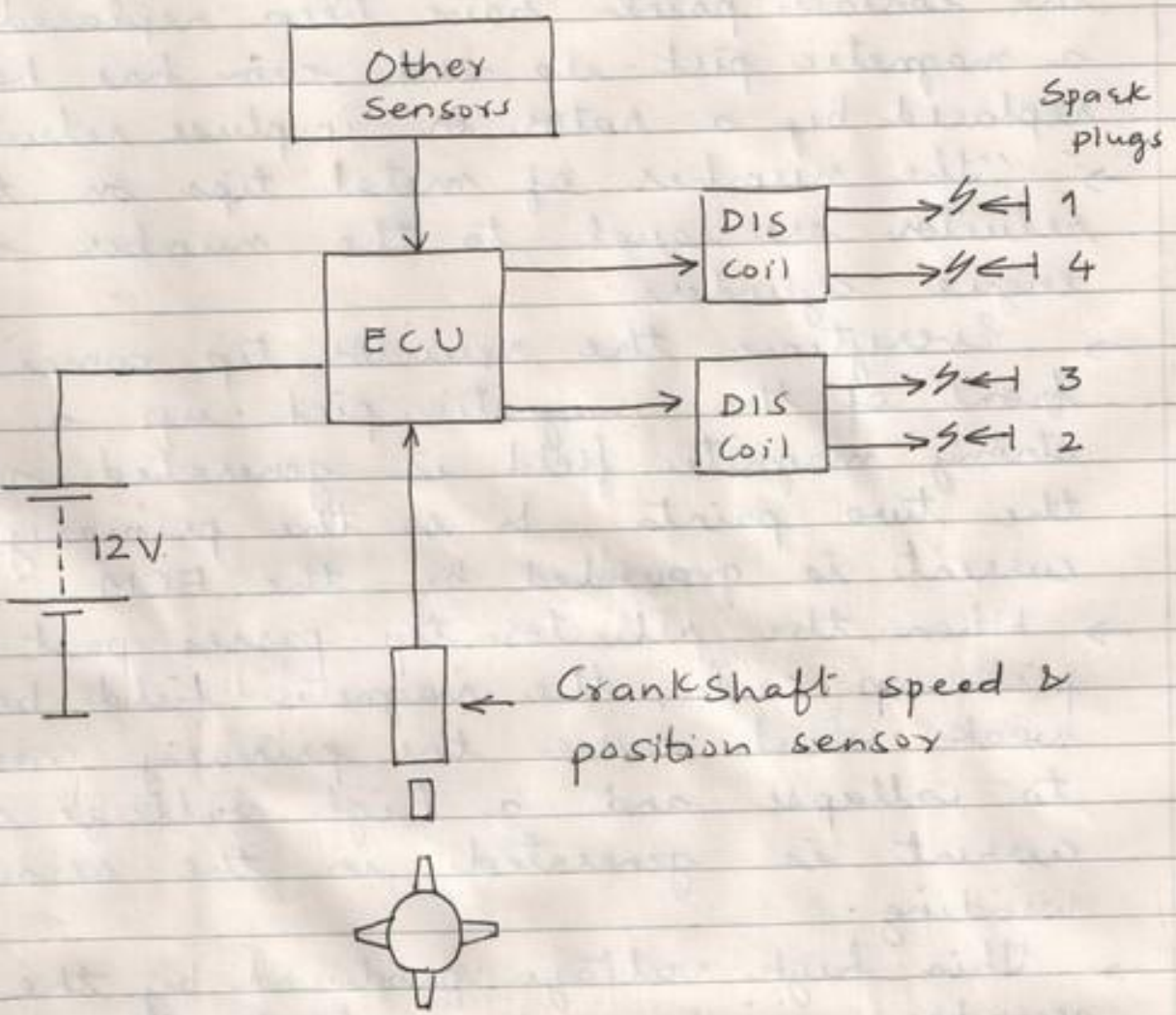
→ Everytime the reluctor tip comes in front of the magnetic pick-up a strong magnetic field is generated across the two points, & so the primary current is grounded by the ECM.

→ When the reluctor tip passes past the pick-up coil, the magnetic field becomes weak which cause the primary current to collapse and a high voltage secondar current is generated in the secondary winding.

→ This high voltage produced by the secondary winding is sent to the distribut rotor to the spark plugs.

(DIS)

* DISTRIBUTOR LESS IGNITION SYSTEM / COMPUTER CONTROLLED COIL IGNITION SYSTEM :-



→ The distributor less ignition system consists of three main components :-

i) An ECU
ii) Crankshaft speed & position sensor
iii) Ignition coil.

→ The system is generally used for four-cylinder engines.
→ The basic principle is that of the 'lost spark'.
→ The distribution of the spark is achieved by using two double-ended coils, which are fired alternately by the ECU.
→ The timing is determined from a crank-shaft speed and position sensors as well as some other sensors such as engine load, coolent temp, knock sensor etc.
→ When one of the coils is fired, a spark is delivered to two engine cylinders, either 1 and 4, or 2 and 3.
→ The spark delivered to the cylinder on the compression stroke will ignite the mixture.
→ The spark produced in the other cylinder will have no effect, as this cylinder will be completing its exhaust stroke.