

CHAPTER 6 – IGNITION SYSTEM

CONTENTS	PAGE
Faraday's Law	02
The magneto System	04
Dynamo/Alternator System	06
Distributor	08
Electronic System	10
Spark Plugs	12

IGNITION SYSTEM – Faraday’s Law

The Law

“The induced electromotive force or EMF in any closed circuit is equal to the time rate of change of the magnetic flux through the circuit”

Principal of Operation

Put simply: - everytime a magnetic field (flux) passes through the wires of a circuit, a pulse of electricity (EMF) is generated in those wires.

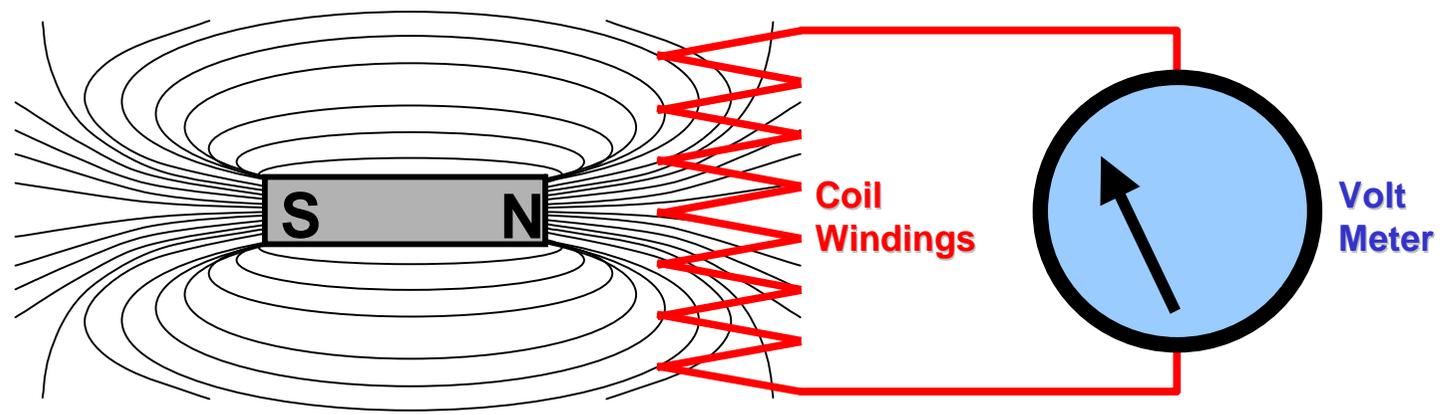
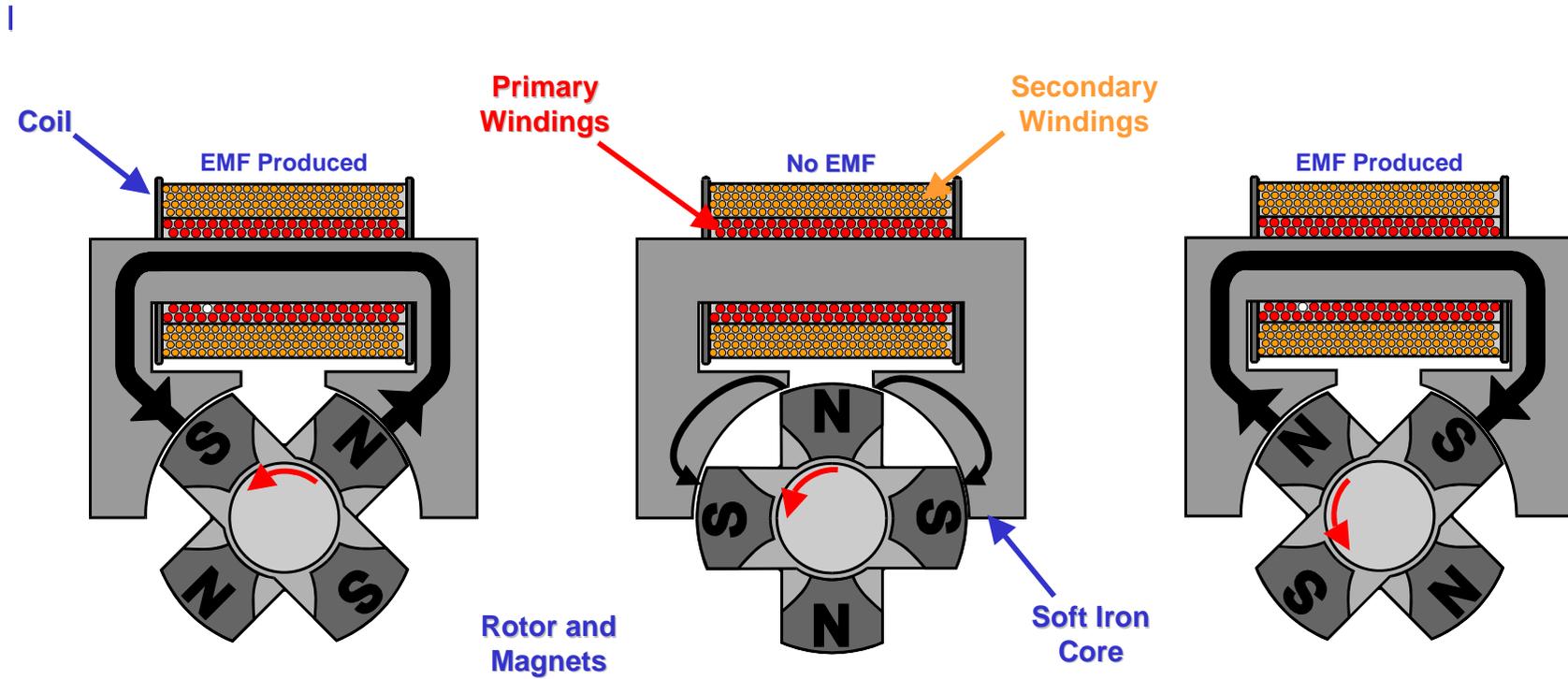
This happens both when the magnetic field builds up and when it collapses. Continuously passing magnets close to wires will continuously produce pulses of electricity; this is how a Magneto generates power.

Magnetic field lines of force flow from the magnets’ north pole through the soft iron core to the south pole. The magnetic pole positions are continuously (resulting in a magnetic flow through the soft iron core in one direction, then no flow, then the flow reversed etc) changed by mechanical drive from the engine rotating the rotor with the magnets attached. For each rotation of the rotor, the magnetic field in the soft iron core will build and collapse four times

The coil and ignition circuit consist of two sub-circuits: the primary windings, which carries low voltage; and the secondary windings, where the high voltage pulse is generated.

Each time the soft iron core is magnetised and also then demagnetised, an EMF is generated in the primary coil windings.

This power is used to generate an EMF in the secondary windings (the greater the number of turns of wire in the secondary windings the greater the power generated), which is used to provide the spark in the spark plugs, the correct timing and sequence being controlled by the **Distributor**, see pages 04 and 08.



IGNITION SYSTEM – Faraday's Law

IGNITION SYSTEM – Magneto System

Aircraft Systems

In aircraft the magneto provides power only for ignition, and, for safety reasons, two completely separate systems are installed. Each system can be selected individually, or both to operate at the same time.

System Operation

Magneto is a complete ignition system in a single unit (except the spark plugs and ignition switch) consisting of the power generation, spark generation and distribution components.

Contact Breaker Points

Inside the unit is an engine driven shaft, geared to rotate at half engine speed. On the shaft is a four lobe cam (for a four cylinder engine), and mounted on the top end is a rotor arm inside the cap; the cap holds the output terminals connected to the spark plugs via high tension leads.

As the cam rotates, the lobes open and close the points four times per distributor shaft revolution. The rotor arm directs the spark surge via the output terminals in the cap and high tension cables to each spark plug in the correct sequence for the combustion stroke i.e. in a four cylinder engine - 1, 3, 4, 2.

Spark Generation

When ignition switch is in the 'on' position and the points are closed, current flows from the primary windings through the airframe (earth side) back to the magneto, completing the circuit.

When the points are opened by the cam, the primary winding flow stops, causing the magnetic field generated in the primary winding to collapse and cut across the thousands of turns in the secondary winding. This collapse immediately induces a high voltage current in the secondary winding, which is directed by the rotor arm to the spark plugs. This power surge is sufficient to produce a spark at the plugs, thereby igniting the air/fuel mixture.

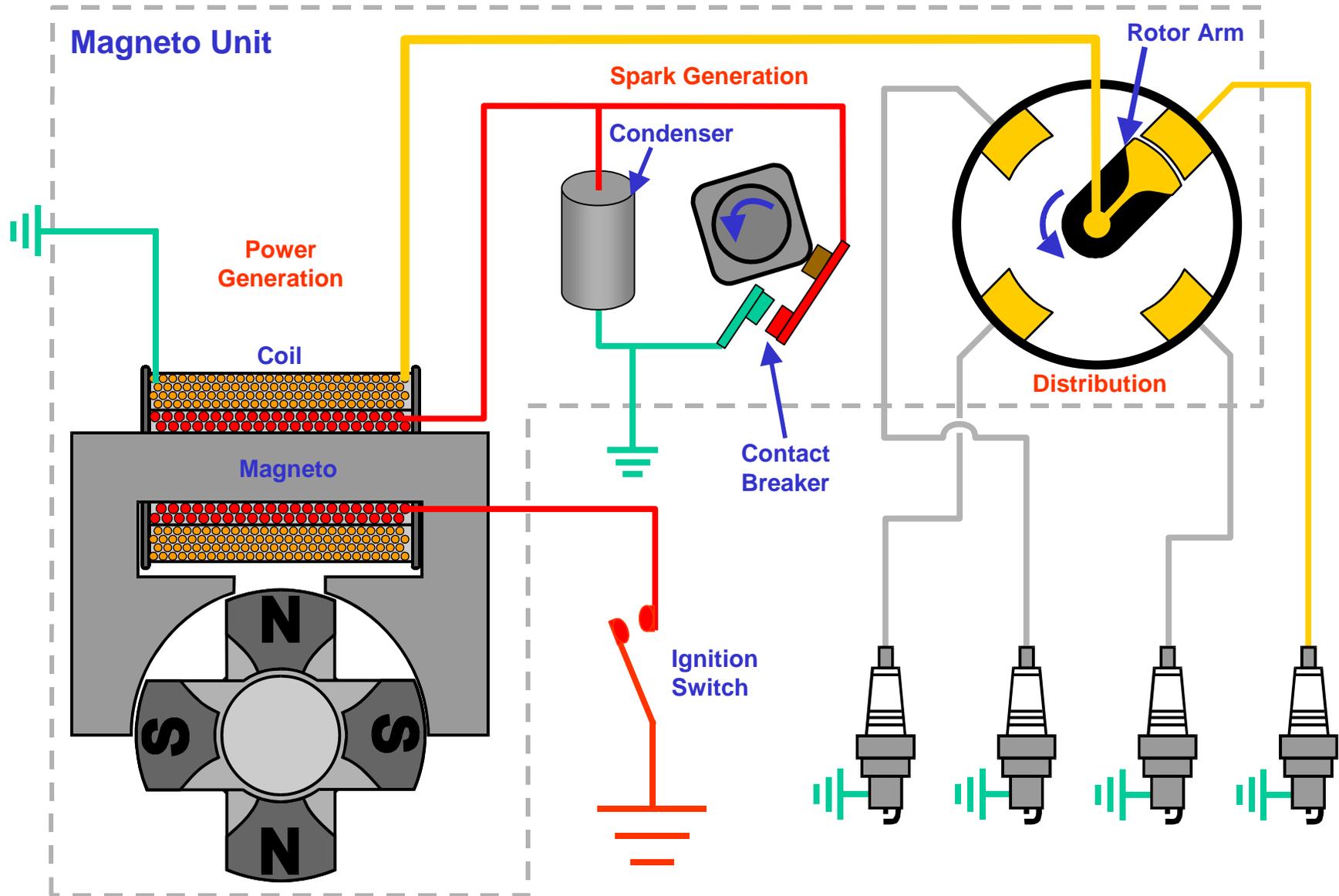
Condenser (or Capacitor)

The condenser or capacitor has two functions: -

1. The condenser absorbs power generated when the magnetic field in the primary windings collapses. This energy could cause arcing and pitting on the contact breaker points, absorbing this energy suppresses the arcing.
2. The absorb power is then discharged on the rebound next time the contact breaker points open causing the magnetic field in the coil to collapse far quicker giving a much stronger spark at the spark plugs.

Note 1: The foregoing descriptions of the contact breaker, condenser and rotor arm operation are the same for all mechanically timed ignition systems.

Note 2: The description of the spark generation via a coil is the same in all systems.



IGNITION SYSTEM – Magneto System

IGNITION SYSTEM – Dynamo/Alternator System

In the dynamo and alternator systems the battery provides the power to the primary windings in the coil unit. The battery is continuously re charged by the dynamo (on earlier systems) or the alternator (on later systems).

The operation and interaction of the coil primary and secondary windings, the points, condenser and rotor arm are the same as described previously on page 04.

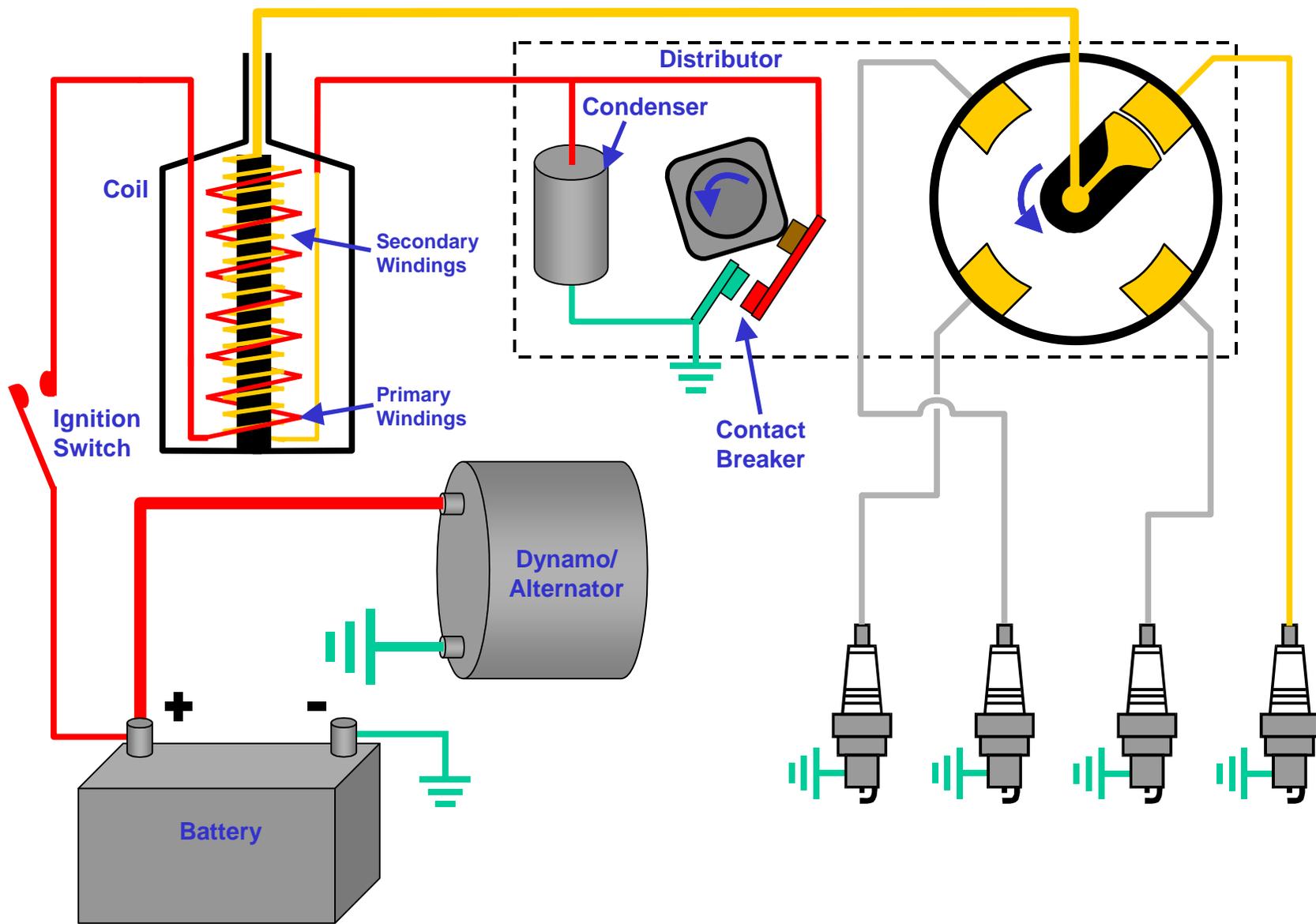
Generally these systems feature the following: -

One coil, with the primary and secondary windings, plus a soft iron core which concentrates the magnetic field.

One engine driven distributor, containing the condenser, points and rotor arm; and other features, see page 08 for more details.

Some systems have multiple coils and or distributors.

Typically, 'V' engines feature a distributor and a coil for each bank of pistons.



IGNITION SYSTEM – Dynamo/Alternator System

IGNITION SYSTEM – Distributor

The Distributor consists of the following components: -

The drive shaft – driven by the engine (usually off the camshaft) which rotates inside the body. The shaft is in two parts, the lower part drives to upper part through a centrifugal advance mechanism.

Centrifugal Advance Mechanism – consisting of weights held inwards by spring force and thrown outwards by centrifugal force overcoming the spring force. This alters the position of the cam (integral with the top part of the shaft) relative to the input drive shaft (crank angle and of course the piston position). This can alter the ignition advance by up to 30 degrees.

This is required at higher engine speeds because of the speed of air/fuel mixture combustion.

The engine runs more efficiently when maximum expansion of the burnt gasses occurs just as the piston is starting its downward power stroke.

At idle, this is achieved with the ignition occurring at about 5 degrees before top dead centre, (TDC). At higher speeds, the fuel air mixture does not burn faster, so the ignition point needs to be advanced to start the combustion process earlier.

Vacuum Advance Mechanism

This mechanism consists of a plate, on which the contact breaker points and condenser are mounted, and which its angular position is changed by the vacuum advance unit, attached to the outside of the body. This is sensing the partial

vacuum in the engine inlet manifold, near the carburettor throttle valve, when cruising at part throttle to further advance the ignition timing by up to 20 degrees. This generally increases fuel economy particularly with weaker mixtures.

The Cam, Contact Breaker Points, and Condenser

Operation as described on page 04.

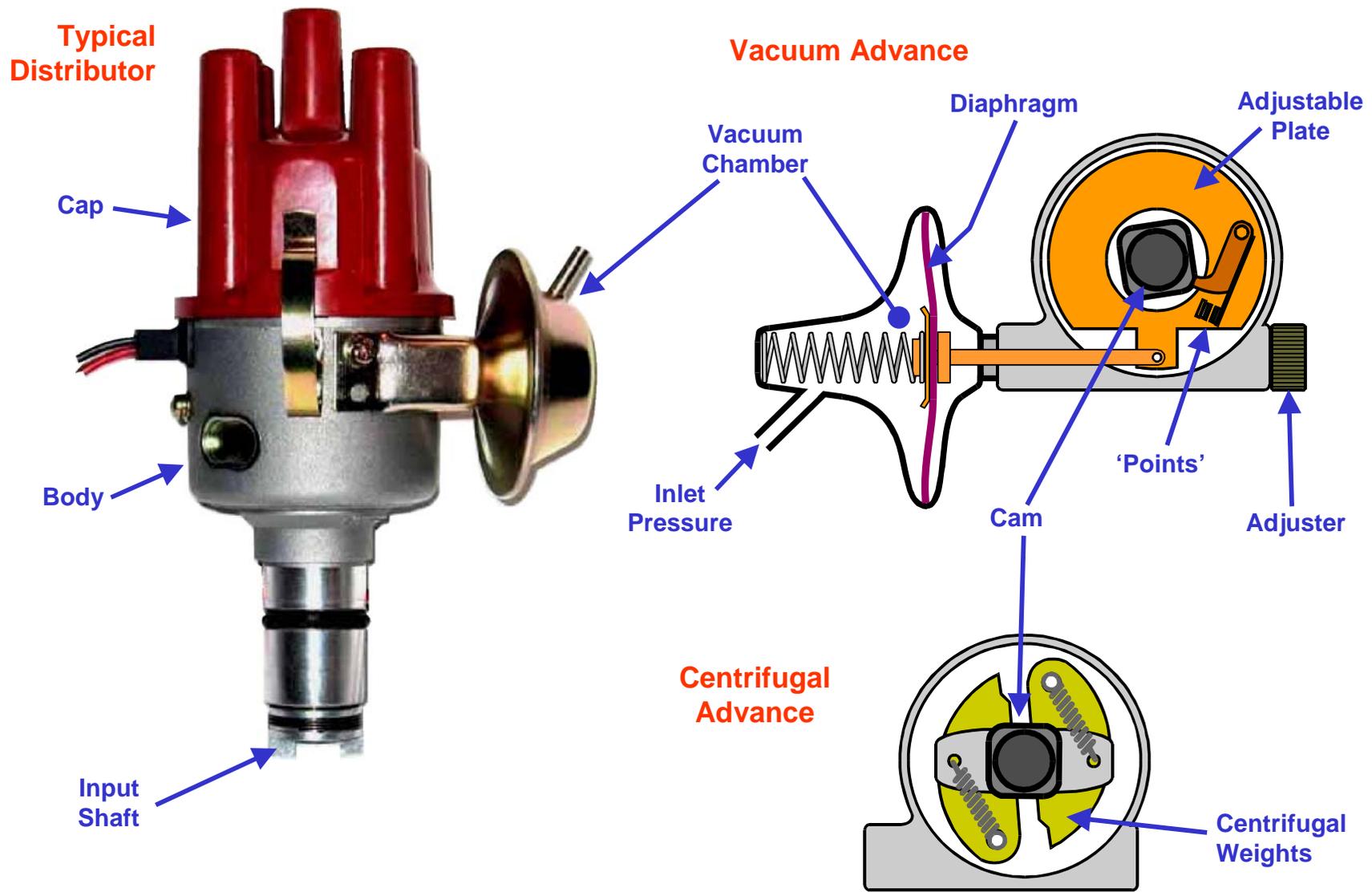
The Cap – clipped to the top of the body. Inside are the output terminals and high tension connections on the outside.

The Rotor Arm – a single position push fit onto the upper end of the drive shaft. This rotor connects the high tension pulse from the coil secondary windings through the distributor cap mounted terminals and high tension cables, to the right spark plug.

Initial timing set up

The distributor is held in place by a clamp, loosening the clamp allows the whole distributor to be turned in its mount.

This is usually set by aligning the No1 piston at just before TDC (timing marks are provided to ensure correct positioning), and then moving the distributor until the contact breaker points just open. Tighten up the clamp ensuring the distributor doesn't alter its angle.



IGNITION SYSTEM – Distributor

IGNITION SYSTEM – Electronic Systems

Mechanically timed ignition systems suffer some limitations as follows: -

The contact breaker points deteriorate and need regular resetting and cleaning.

Contact breaker current is limited to about 5 amps or arcing occurs; this limits the spark at the plugs.

At higher revs the points can bounce on the cam when they close; this can weaken the spark.

At higher revs the points are close for a very short time (called the 'dwell' angle) this produces a weaker spark. This is worse on six or more cylinder engines.

Despite these problems, these systems were used almost universally until the 1970s when electronic systems started to appear.

Electronic Systems Operation

These systems initially continued to use the mechanical contact breaker points, but at very low trigger currents; and only as crank angle position switches.

Now the distributor as previously described has all but disappeared, to be replaced by a 'solid' state timing sensor and an Electronic Control unit (ECU). The timing sensors were either optical or more commonly a magnetic system.

The ECU switches a large flow of current through the coils, creating the spark. The unit also ensures the correct firing sequence.

Engine Management Systems (EMS)

With the development of fuel injection system (because of emission control legislation) it became logical to combine fuel and ignition control in one system.

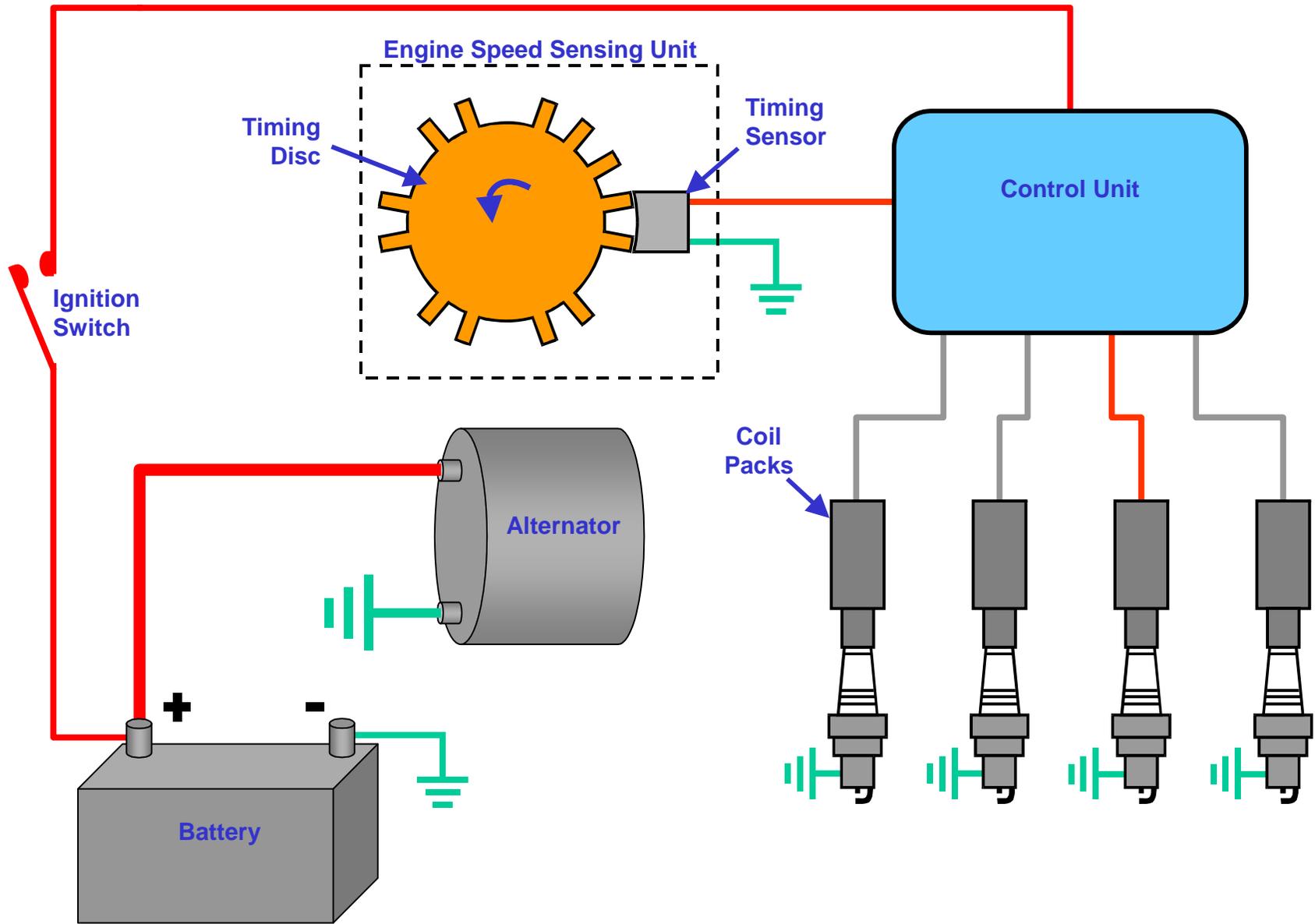
The ECU in these systems receive numerous signals from around the engine such as engine speed, crankshaft position, airflow, throttle position engine and air temperature, unused oxygen in the exhaust gases amongst others.

The ECU compares these inputs with data or 'maps' pre-loaded into its memory, and can supply the correct amount of fuel and precisely time the ignition to ensure the most efficient combustion of the air/fuel mixture.

Commonly, on most systems, each spark plug now has its own coil which can produce a current of approximately 30,000volts at the spark plugs.

Advantages

AS well as efficient combustion of precisely the correct amount of fuel, these systems have become extremely reliable and almost maintenance free, apart from having to changing components when they fail.



IGNITION SYSTEM – Electronic Systems

IGNITION SYSTEM – Spark Plugs

The first commercially available spark plug was invented in 1902 and although detailed changes have been made, the basic construction has been the same since then.

Operation

Simply, when supplied with a high voltage pulse, a spark jumps across from the inner to the outer electrode.

For good performance, the gap needs to be set correctly; too far apart and the spark may not jump the gap, too close and the spark may not be big enough to initiate combustion.

The gap can increase due to erosion and could be bridged by contaminants as a result of the combustion process.

Regular cleaning and gap adjustment is necessary.

Cleaning is best achieved by fine grit blasting; small mains or battery powered units are available.

Adjustment is by moving the outer electrode.

In most systems, the gap is set between 0.5mm to 1.0mm, commonly about 0.75mm; the actual gap setting can be found in the maintenance manual or owners handbook.

Plug Types

Variances in plug design are necessary to be able to fit different engines, therefore it is essential the correct plug is used.

Differences can be as follows: -

Thread length, type and diameter.

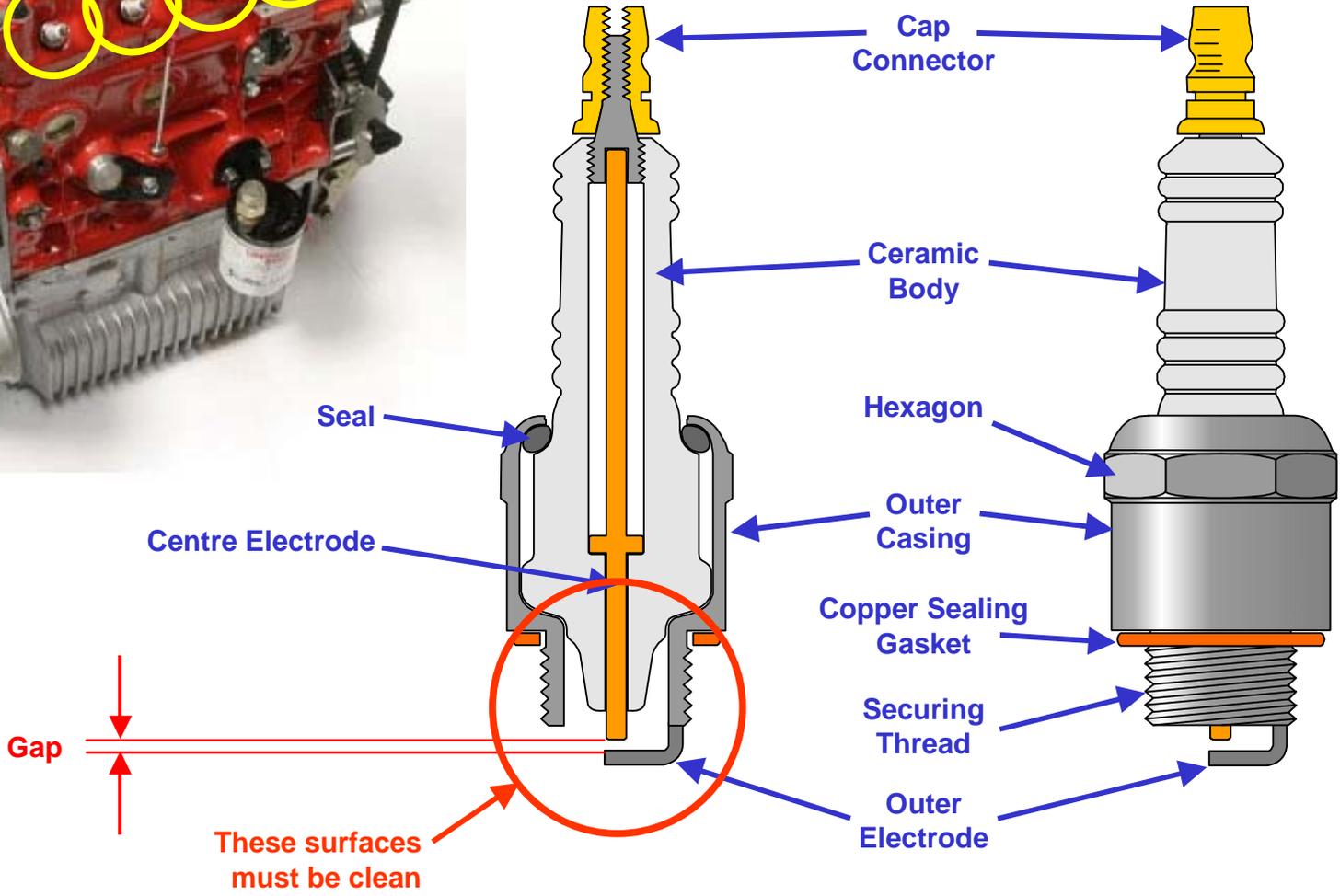
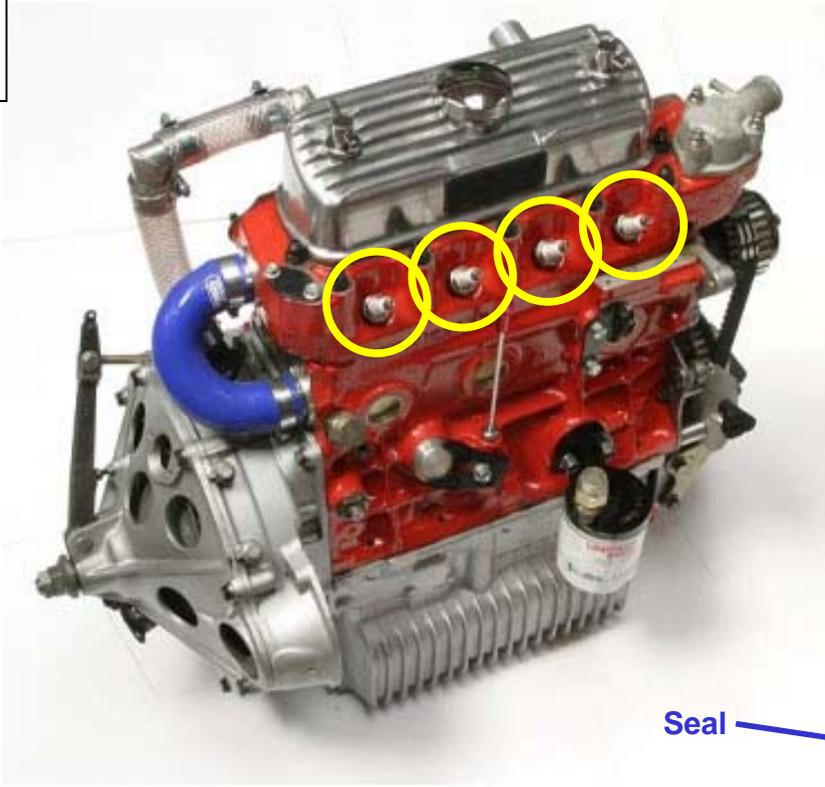
The length of the ceramic insulator around the centre electrode i.e. 'cold' or 'hot' plugs

Cold plugs have a short insulator, which allows heat to be transferred to the engine easily. Used in high performance engines to prevent pre-ignition* through over heating

Hot plugs have a long insulator which has a longer heat flow path, therefore the immersed end of the plug gets hotter. Used in low performance engines where the higher plug temperature burns off any deposits reducing the possibility of pre-ignition.

*Pre-ignition is where the air/fuel mixture is ignited by extremely hot deposits before the spark can initiate combustion.

A



IGNITION SYSTEM – Spark Plug