TECHNICAL DATA SHEETS

INTRODUCTION

On our beloved old cars is an ignition system from the dark ages, however if it is understood and maintained it can provide a good reliable source of ignition for the engine. The operation of the system appears simple enough, however if looked into in some depth it soon becomes a thing of marvel, invented in the days where true innovation took place, think of it, this system has been around for 50-60 years before electronics took over.

Quite simply you provide the coil with 12 VDC and use the points to switch the current and generate a big fat spark which makes the engine work, oh and there is the condenser, the bit nobody knows why it is there

The next bit is quite hard work to follow, I've spent my whole career in electronics of some sort or another and I confess to not really understanding the crux of it all. I am not concentrating on the plug leads or distributor cap as these are merely a delivery method of the high voltage and are pretty well understood by most folk, I have concentrated on how the high voltage is created.

ESSENTIAL INFORMATION

This information should help understand the text in the 'How it really works' section.

DC verses AC

DC current is the stuff you get from batteries, nowhere else. All other DC is manufactured from AC such as in our cars. The engine drives the alternator which generates 3 phase AC current, this is smoothed by virtue of a full wave rectifier which gives a pulsed output, the connection to the battery smoothes this out to DC.

AC can be generated from DC when you flick a switch on/off or off/on. It is this transition from 12v to 0v or from 0v to 12v that gives high speed (frequency). Remember this, we use it later.

COIL

The coil is a transformer, nothing more, nothing less. There are two windings; the primary and the secondary, the primary connects to the ignition key and the contact breaker points, the secondary connects to the spark plugs both are wound round the same iron core.

A coil only really does it's thing when AC current is present, when DC is applied it simply passes current through the primary and generates (charges) a magnetic field around the core. The magnetic field is the magic part of it, physics states that when a moving magnetic field comes up against a coil an EMF (electro motive force, or current) will be generated in the coil, so basically the primary charges the iron core up with magnetism and when the current stops flowing the magnetic field collapses and passes the energy to the secondary. The faster this happens the larger the spark will be because the coil gives up it's energy faster.

One more trick up the transformers sleeve is that it can be a voltage multiplier, if the primary has 1 turn and the secondary has 4 turns, the 12v on the primary will get turned into 48v on the secondary but with 4 times less current.

A coil is a low resistance with DC applied but is high resistance to transients such as when the points close.

CONDENSER

The condenser (real name is Capacitor) is a device used to speed up the process of the coil by preventing the primary of the coil discharging through the points. This is very complex and beyond this document but I will try and explain.

A capacitor is the opposite to a coil with DC applied a capacitor is blocking device; no current will pass, with AC a capacitor becomes a low resistance, the higher the frequency the lower the resistance.

If the condenser wasn't fitted, as the points open a spark will form across the points because the coil will notice the points open, the voltage will rise in the primary and secondary. But as the voltage rises in the primary (forget the secondary for the moment) it's ability to jump gaps increases, as the points open further, the voltage rises further and jumps the gap and so on until the magnetic field has collapsed through the primary, the secondary will have mirrored this but it will not have reached enough voltage to jump the plug gap.
The small spark you see when the points open is a small percentage of the energy dissipating during the time it takes the condenser to charge up.

The condenser will charge up to the potential on the coil side of the points immediately the points open and store the energy, as this happens immediately the current will stop flowing in the primary instantly and the magnetic field will collapse just as instantly. The voltage will rise in the primary to upwards of 200 –300volts but as it is a voltage multiplier the secondary will wise to this multiplied by how many turns it has over the primary; say 100, meaning the secondary will get to 20,000 to 30,000 volts and continue to rise until the energy is dissipated in a spark across the plug; just where you want it.

So, although the condenser is the least thought about component it is actually the most important.

HOW IT REALLY WORKS

The points are quite simply a mechanical switch. The lobes on the engine driven cam inside the distributor pushes on the 'heel' of the points to open them and a spark happens, you will need about 12,000 volts to generate a spark across a spark plug with a 0.025" gap in the open air, however put this inside a 10:1 compression ratio engine and more voltage is needed, open the spark plug gap a bit and more still is needed; in fact a modest little 1300cc engine uses about 30,000 volts to generate it's spark.

Obviously you cannot simply switch 30,000 volts with the points because it would jump ½ an inch in any direction in free air and would be a nightmare to control, so a coil is used.
A coil is simply a step up transformer with 2 coils of wire wound round the same iron core, nothing else, there are only two rules;

1. The coil must have time to charge up, and
2. It must have the current turned off as quickly as possible.

The coil is a very efficient device, about 98%, but it only converts energy it cannot generate it! So if the resistance of the coil limits the current to 5 Amps in the primary the total power available is 5A times 12V which is 60 Watts, so the output of the coil will be 60 Watts times 98% which is 58.8 Watts, the other 1.2 Watts heat the coil up and is wasted. Using our 30,000 volts means we only have 0.0019A or 2 mA. Hence you will get a big shock but it won't kill you.

The way the system works is this. When the points close current starts to flow into the primary side (marked +) of the coil and it is at this point we have to do a bit of transformer theory. When voltage appears at the coil a reverse voltage (called a back EMF) is immediately generated in the coil, this is almost the same size as the applied voltage so the current is actually very small and it takes time to charge the coil up, or generate the maximum magnetic field. This time is taken care of by virtue of the points being closed, aka the Dwell angle; normally 32° of the available 360°. This is rule 1.

As the cam lobe reaches the part where it starts to open the points this is where the condenser plays its part. As I said earlier rule 2 states the current must be turned off very quickly to get the big spark. Points open mechanically which in electrical terms is VERY slowly, as they open the stored magnetic charge in the coil tries to dissipate back into current and forms a spark across the points, this means the primary of the coil discharges to earth through the points and doesn't generate much of a voltage in the secondary, plus as the magnetic field collapses the voltage in the coil primary increases in size towards several hundred volts which actually gives a bigger spark across the points helping the coil discharge, the result is no spark.
The instant the points open the condenser stores this energy from the primary of the coil which means there is no discharging of the primary.

I must now explain how a coil works, there are 2 coils wound a single iron core, one with few turns (primary) and one with many turns (secondary), these coils are not electrically connected, the only common part is the iron core. The current in the primary builds up a magnetic field in the iron core and it is this magnetic field that that connects the two coils. The coil will just sit there with current flowing in the primary just maintaining the magnetic field until the current stops flowing and it is then that things get really teccy! Kirchoff says that when you move a magnet close to a coil of wire a voltage will be generated in the coil. So, when the magnetic field collapses in the primary it is the same as a moving magnet so it generates a voltage in the secondary but as the secondary has many turns, many times more voltage is created.

Going back, the condenser allows the magnetic field to collapse quickly and generate the large secondary voltage used at the spark plug to create the spark.

In real terms there is not a single spark at the spark plug, the inductance of the coil and the capacitance of the circuit actually forms a tuned or resonant circuit, this results in the current actually making the spark to 'ring' in other words flows one way, then reverses, each reversal is smaller than the last and eventually decaying to the point where no more sparks can be produced. This happens so quickly that it is not visible to humans and an oscilloscope is needed to see it.

One more thing, sparks were in fact the earliest form of radio transmission, the size of the spark was altered to transmit data so the ignition system of the car is in fact a primitive radio transmitter hence the crackling on the radio when the engine is revved. Indecently the way this interference is prevented from getting to the radio is what's called a 'Faraday cage'. Basically this is the all the metalwork of the car surrounding the engine including the bonnet,

ever wondered why there is an earth strap going from the car to the bonnet? Well that's why, try taking it off and see how rubbish the radio sounds.

ELECTRONIC IGNITIONS

A coil is still used but the method of turning off the current is now electronic, electronic devices switch thousands of times quicker then mechanical points and as such have no need for a condenser because they have a very high 'off' resistance and prevent the primary from discharging. Any capacitors on an electronic ignition set up are for interference suppression only.