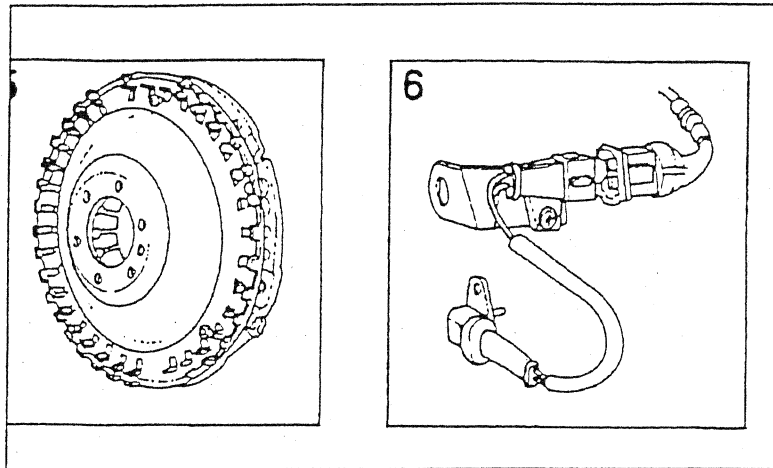


ELECTRONIC IGNITION

Crankshaft Position Sensor

- The crankshaft position sensor (CPS) is used more commonly on mapped ignition systems. It works on exactly the same principle as the permanent magnet pick-up. Generally speaking the CPS has more reluctor teeth than the permanent magnet type, this is to enable the CPS to indicate engine position to the control unit. The CPS can be mounted inside the distributor body or more commonly can be mounted by either the crankshaft pulley or flywheel.



Electronic Ignition Systems

Electronic ignition systems are claimed to overcome the disadvantages of the contact breaker systems. The early systems however were only marginally better than the contact systems they replaced.

The major disadvantages of the early systems was the dwell angle, this remained constant with an increase of engine speed. Under these conditions the coil saturation time decreases and coil output drops as a result.

Over the past few years the introduction of the constant energy variable dwell system has improved the spark efficiency by maintaining a constant coil saturation in respect to engine RPM.

If the ignition coil secondary voltage is increased, two main advantages are gained. These are:-

1. The higher output will enable the coil to fire spark plugs that are worn or over gapped. The interval between servicing can therefore be increased without a drop in engine performance.
2. The high coil energy will ensure that the plugs fire for a greater length of time. The mixture strength can be weakened, thus giving an improvement in fuel consumption and reducing harmful exhaust gas emissions.

The very early type of electronic ignition systems retained the contact breakers in the distributor, though the contacts did not carry full primary current, but were used to switch a power transistor in the amplifier module. The amplifier is capable of switching a much higher current than a set of contacts. This type of system included the Lucas TAC and the Sparkrite "piggy back" range.

In later generations of electronic ignition a pulse generator takes the place of the contact breakers. In the electronic type of ignition, three events in sequence cause the spark plug to fire.

1. The pulse generator signals the amplifier.
2. The amplifier turns the primary circuit off.
3. The coil secondary voltage fires the spark plug.

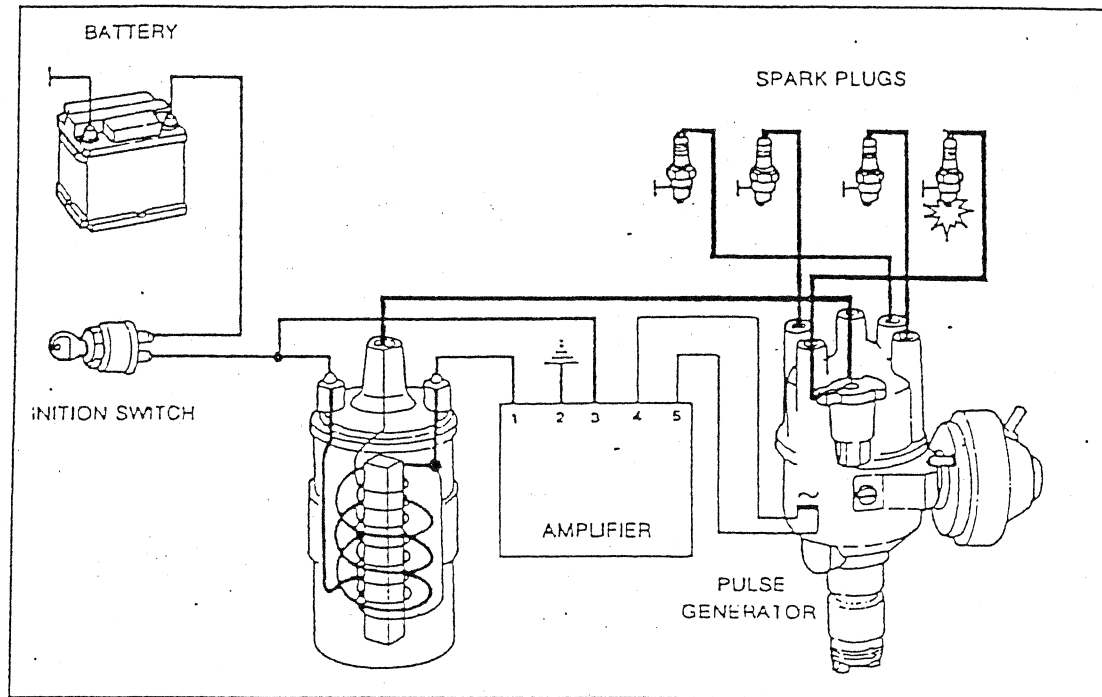


Figure 10 Electronic Ignition System

Electronic Ignition System Types

In order to simplify the explanation, the systems have been divided into four different types :-

1. Magnetic inductive fixed dwell.
2. Magnetic inductive constant energy variable dwell.
3. Capacitive discharge systems.
4. Mapped or Programmed systems.

1900

1. At the time the electronics in this system were very advanced, but to look at one today is like looking back in time. The components of the day were not really "man" enough for the hostile world of the motor car.

2. The car manufacturers did not help matters by fitting components at the hottest points of the engine, i.e. in the Vee of the engine block or over the exhaust manifolds.

Ford Duraspark II

This system was fitted to Ford V6 engines up until 1983. It comprises of a permanent magnet distributor, an electronic control unit, a conventional ignition coil and a ballast resistor. The system is of a fixed dwell design, which means that the distributor pick-up is responsible for turning the ignition coil on and off.

The primary current will flow whenever the ignition switch is in the ignition (on) position. The distributor contains a pick-up coil (stator), which produces a magnetic field. The reluctor (armature), turning with the distributor shaft, causes the magnetic field to build and collapse whenever the reluctors teeth approach and pass the pick-up coil.

The module senses the change in the magnetic field's strength, and turns the coil primary current on and off. This causes the collapse of the magnetic field that has built up in the coil primary winding, which in turn causes the build up of the HT voltage which fires the spark plugs.

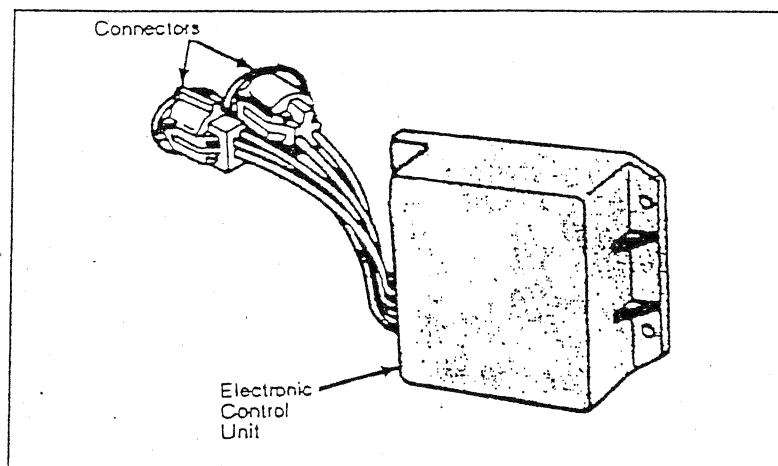


Figure 12 Duraspark Control Unit

Chrysler Hall Effect Ignition System

This system was fitted to Chrysler / Talbot vehicles between 1977 and 1983. The system consists of a distributor with a Hall effect switch (pick-up), an electronic control unit and a conventional coil. The distributor cap, advance mechanism and spark plug leads are conventional in their design.

The Hall effect system has no ballast resistor or by-pass circuit for starting. The distributor uses a Hall effect with a special rotor. The rotor is equipped with 4 shutter blades that pass through the hall effect switching unit.

A square wave signal is generated by the Hall effect unit, which is then transmitted to the

electronic control unit via the 3 cable lead. No moving parts contact each other in the distributor, therefore, there is no need for regular adjustment.

The electronic control unit is located in a large aluminium housing mounted on the O/S fitch panel. A switching transistor is exposed on the top of the unit for cooling. The control unit is connected to the rest of the system by a 5 pin "D" shaped connector.

The electronic control unit functions whenever the ignition switch is turned to the "start" or the "on" position. It allows current to flow through the primary side of the coil, creating a magnetic field.

The hall effect switch produces the square wave which is transmitted to the electronic control unit. As the shutter blades (on the bottom of the rotor) approach and pass through the Hall effect switch, a change in the voltage occurs. This signal is transmitted from the switch to the transistor in the control unit.

The transistor turns the primary circuit of the ignition coil on and off. This break in the current flow causes the collapse of the magnetic field in the primary winding, and in turn causes the build up of the HT voltage which sparks the plugs.

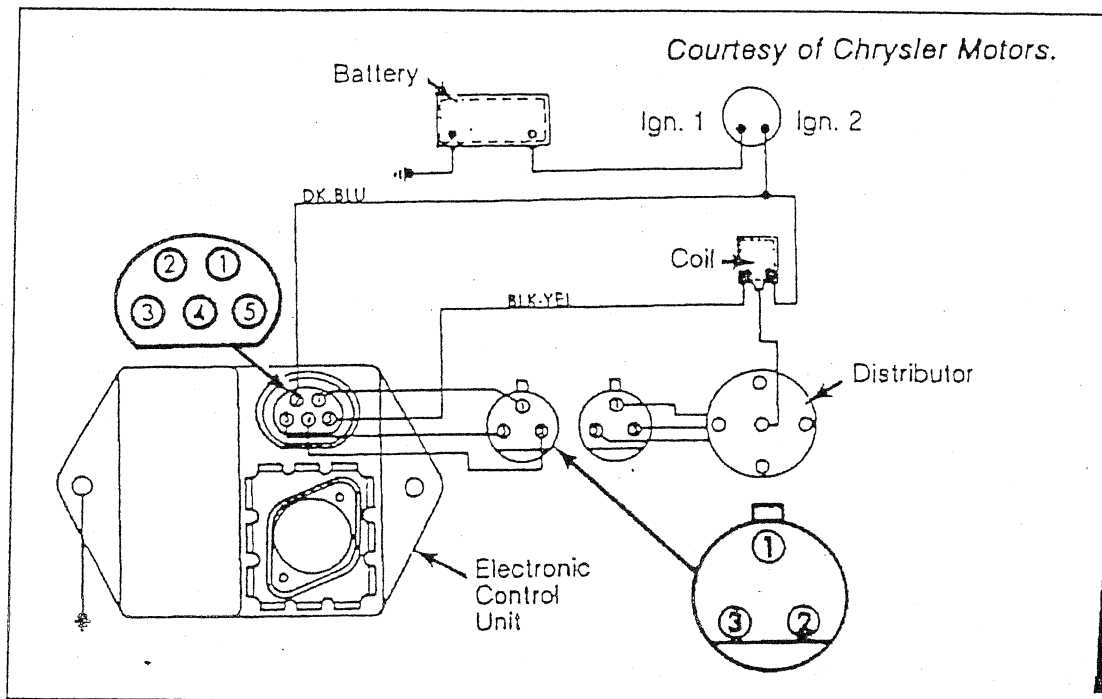


Figure 13 Hall Effect Circuit

Constant Energy Systems

On any magnetic inductive ignition system with a fixed dwell angle the actual dwell time will reduce as the engine speed is increased. For example, on a 4 cylinder engine with a 40 degree dwell angle, at 1000 RPM the actual dwell time is 13ms.

But at 4000 RPM the dwell time is reduced to only 3ms.

With the constant energy variable dwell systems the dwell angle is increased as the engine speed is increased to help compensate for a reduction of dwell time.

The point of firing is again triggered by the pulse generator but the point at which the power transistor is switched back on again is determined by the amplifier.

The above systems require a pulse generator to switch the amplifier module or electronic control unit (ECU).

The constant energy system went a long way to improve the output of the ignition coil, this in turn allowed for leaner air / fuel ratios and therefore cleaner more efficient combustion.

The drawback with this system is that it still retains the mechanical and vacuum advance mechanisms that were common on the contact breaker ignition types. This timing control is not accurate enough for today's emission legislation or the requirements of engine power output by the customer.

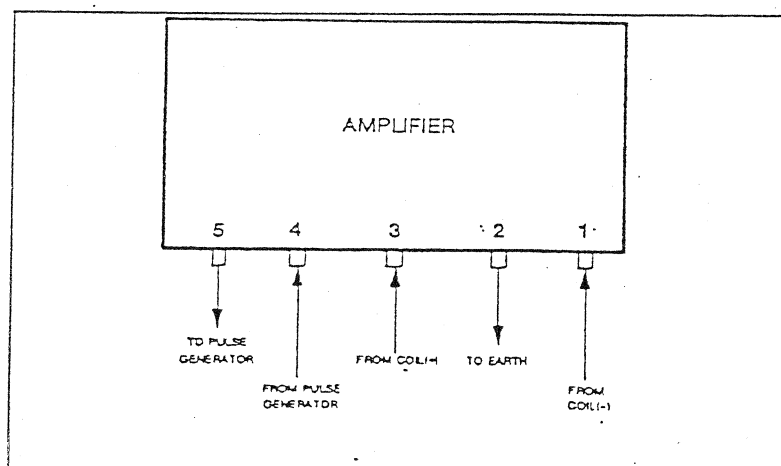
Electronic Ignition Amplifiers

The number and arrangement of terminals to the ignition amplifier varies with the different makes and models of ignition systems and the type of pulse generator fitted.

A typical amplifier that is triggered with a permanent magnet pulse generator will have a minimum of 5 terminals connected.

If the amplifier is triggered by a hall effect generator it will have at least 6 terminals connected.

The example shown below is typical of the magnetic pulse generator type.



Note. A hall effect generator, would have an extra terminal to feed the hall effect circuit.

The purpose these connections is as follows :-

Terminal 1. This carries the current from the negative terminal of the coil to the power transistor in the amplifier module.

Terminal 2. This terminal carries the current from the power transistor to the amplifier earth.

Terminal 3. This is connected to the ignition switch via the coil SW terminal and is used to provide power for the amplifier.

Terminals 4 & 5. These terminals are connected to the magnetic pulse generator and are used to carry the signal pulse to the power transistor in the amplifier.

Note. The terminal numbers will alter from model to model, for this reason manufacturers data should be checked before working on an unknown system.

Amplifier / Module Defects - No Start Conditions

If an amplifier becomes defective in such a way that it causes the vehicle not to start, the defect is likely to be one of the following :-

1. Open circuit power transistor

This occurs when the power transistor is permanently turned off. It is the equivalent of a very wide contact gap on a vehicle fitted with a conventional ignition system (i.e. the contacts do not close when the distributor is turning).

2. Closed circuit power transistor

This defect occurs when the power transistor is permanently switched on. It is the equivalent to the contacts being permanently closed (i.e. the contacts do not open when the distributor is turning).

Note. Before testing the amplifier itself it is important to make sure that all of the connections on the amplifier are clean and tight, and that they are connected to their relevant circuits.

To test for a fault on the power transistor first make sure that the pulse generator is functioning correctly (see the section on pulse generators).

Capacitor Discharge Ignition (CDI)

The capacitor discharge ignition system differs from all other coil ignition systems in the way in which the HT voltage is produced.

In other coil ignition systems the spark is produced by the rapid collapse of the magnetic field through the windings. On the capacitor discharge system the HT voltage is produced on the build up of the magnetic field.

This design gives a rapid voltage rise at the spark plug which reduces any tendency for the plug to foul up. The disadvantage of this system is the plug firing time, this is very low with a maximum of around 0.5 milliseconds. The CDI system was used by Mercedes and Porsche on some of their earlier vehicles. The system is also fitted on many motorcycles and marine engines.

A rapid spark rise time was beneficial on early rotary engines and petrol injection systems and was developed mainly for those vehicles, due to their tendency of fouling of the spark plugs.

Note. A special ignition adapter is often required to carry out full testing on this system.

Capacitor Discharge System Circuit Operation

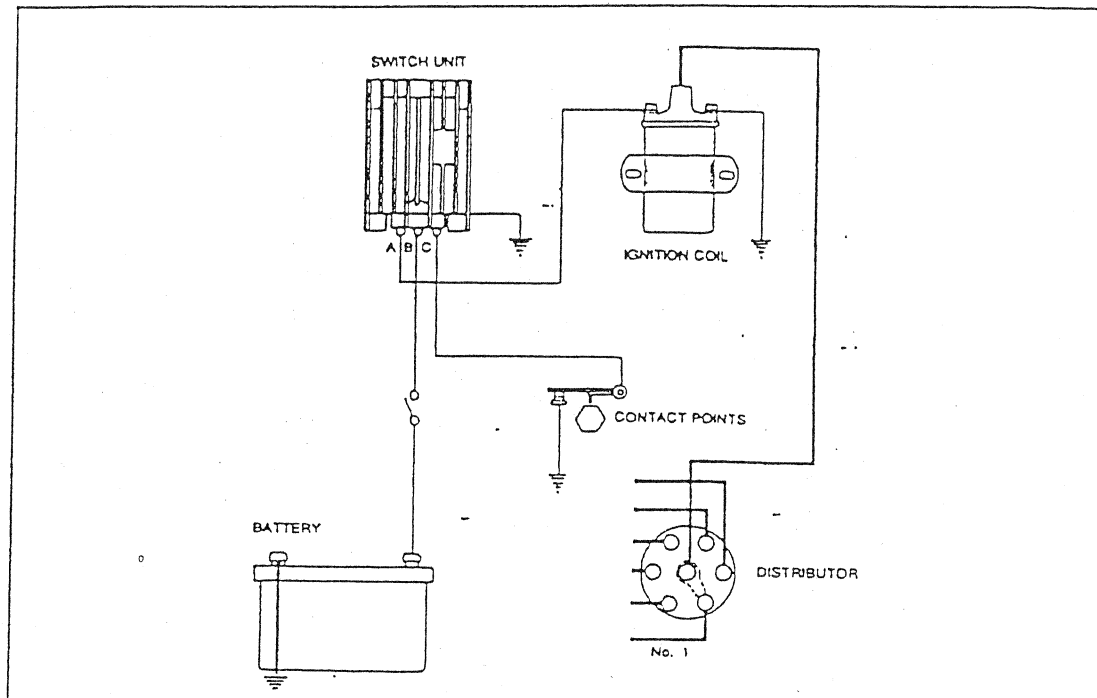


Figure 15 C.D. Ignition System

When the ignition is switched on, battery voltage is applied to terminal B of the switch unit. An oscillator and transformer circuit steps this voltage up to 400 volts AC, this voltage is then rectified to 400 volts DC and is applied to a capacitor.

When the contacts open a silicon controlled rectifier allows the 400 volts DC to be discharged through the coil primary windings causing a voltage to be induced in the coil secondary windings producing the HT spark.

Mapped (Programmed Ignition Systems)

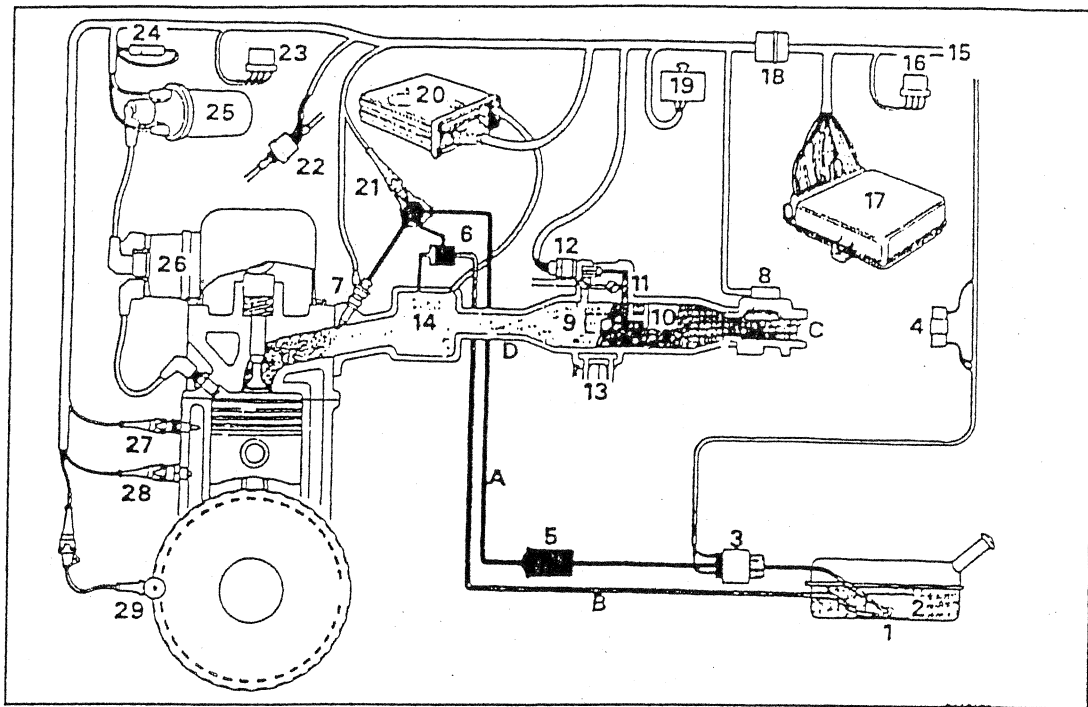


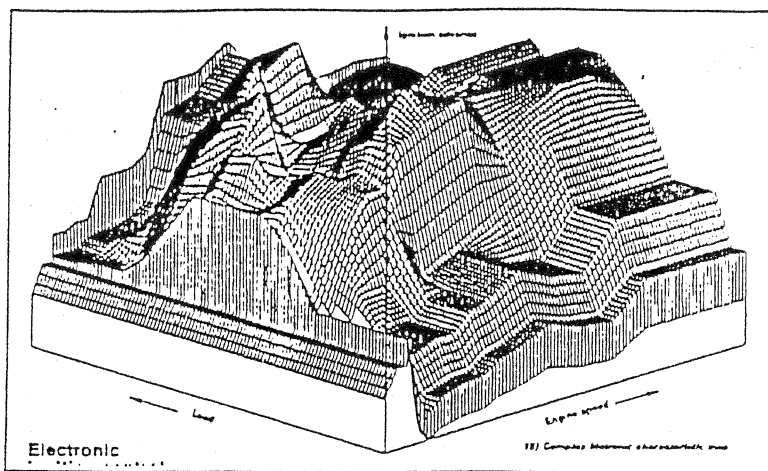
Figure 16 Mapped Ignition Layout

The next generation of ignition systems were of the mapped type. These included AEI Renix, Lucas Programmed, Digiplex and Ford's ESC (Electronic Spark Control).

The main reason for the change onto this type of system was to gain greater accuracy of timing so as to achieve greater power and cleaner exhaust emissions. The function of the distributor centrifugal and vacuum advance mechanisms are now controlled by a micro processor built into the ECU (electronic control unit). The ignition amplifier is also an integral part of the ECU.

Information such as engine speed, crank position, engine load (vacuum), engine temperature and cylinder detonation are received by the ECU. The microprocessor compares these incoming signals with a pre programmed map and decides on the ideal dwell angle and timing point for any vehicle speed and load condition.

The engine speed and position is monitored by a crank position sensor, usually of the permanent magnet type which is located alongside the flywheel or crank pulley, Hall effect generators can be used on this type



of system although it is less common. The distributor on the vehicle is there purely to distribute HT voltages, it is unusual to find any internals in a distributor body. The vacuum (load) Signal is obtained via a manifold pressure sensor. These are often referred to as MAP (Manifold Absolute Pressure) sensors, they can be located either in the control unit or as a separate component.

These systems often contain an anti detonation device, it usually is known as a "knock" sensor. The device is located in the engine block, on vee configuration engines two of these sensors may be fitted.

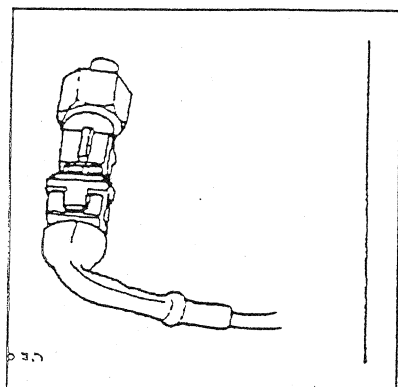


Figure 18
Sensor

The sensor is of the piezo crystal type. This type of device produces a voltage as pressure is applied to it. This same principle is used on cigarette lighters when a "hammer" hits the crystal to produce a voltage which then creates a spark to ignite the gas. On our ignition system the sound of the detonation puts pressure onto the crystal, this in turn produces a voltage, the voltage is transmitted to the ECU where if necessary the timing can be altered. The ECU will only react when the frequency of the noise corresponds to that of engine detonation. Each noise has its own frequency, therefore the ECU will not make a timing adjustment if the tappets are noisy for instance. If the ECU senses engine detonation from the knock sensor it will retard the timing for the particular cylinder that has detonated (this is possible because the

ECU has data on the engine position), the figure that the timing will retard is obviously dependant on the system but a figure of around 2 degrees is common. Over the next several engine revolutions the timing is advanced by small amounts, again figures of around 3/4 degree are common. If the cylinder detonates again during this process the timing will again be retarded. This system is known as closed loop timing control.

The main advantage of closed loop timing control is that the engine can now run much closer to the point of detonation, this allows for a greater power output and a cleaner exhaust emission.

Distributorless Ignition Systems

- The drawback with the programmed ignition systems that it still utilises the distributor cap to direct the spark energy to the correct cylinder. Within the distributor cap and the rotor arm there is a small gap, this is known as the rotor air gap. This small air gap alone can absorb around 5 Kv of spark energy this obviously reduces the power available at the spark plugs. To overcome this problem it would be sensible to do away with the rotor air gap, this is achieved by using a distributorless ignition system.

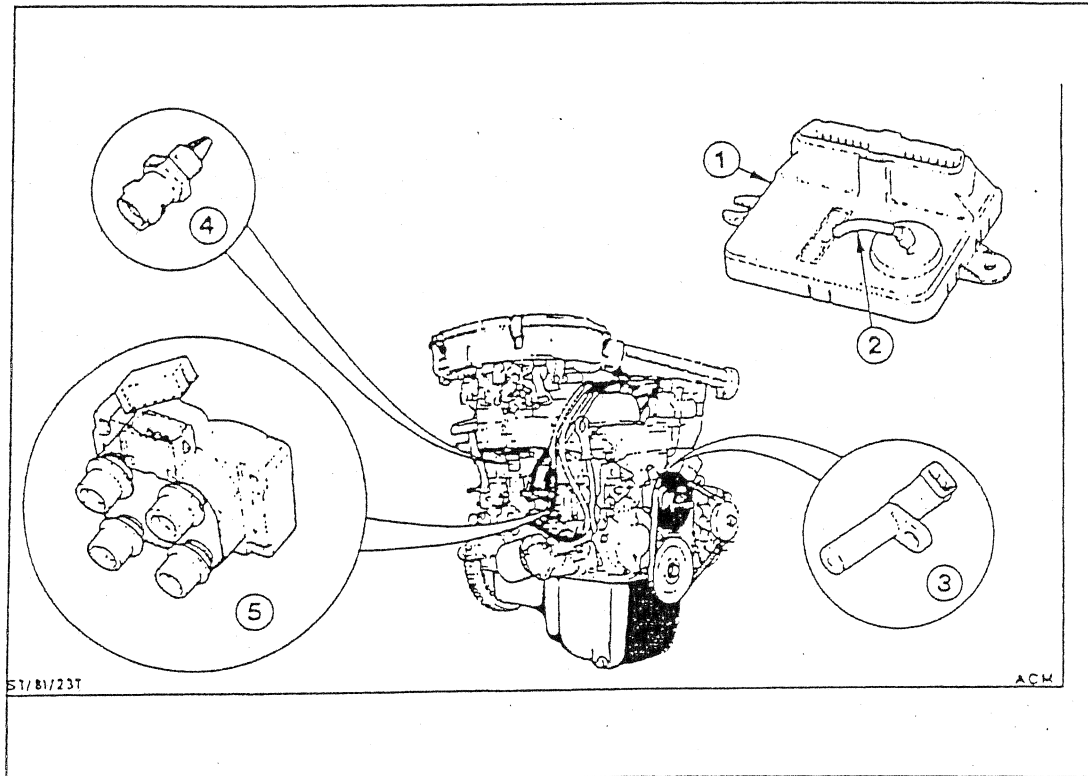


Figure 19 D.I.S. Layout

The system is controlled by a mapped ignition system as described above. The difference between the systems is in the ignition coil. The distributorless system utilises a double ended coil arrangement (Note. The number of coils is dependant on the number of cylinders i.e. 4 cylinders would have 2 coils etc). Each coil is fired independently of the other, and so fires a pair of cylinders that are moving towards TDC at the same time i.e. cylinders 1 and 4 or cylinders 2 and 3 on a 4 cylinder engine. For this reason the system is said to use the wasted spark principle. Of the 2 cylinders approaching TDC, 1 will have air and fuel which is being compressed to ignite and the other will contain exhaust gas which is being exhausted, this later cylinder is the wasted cylinder as it is not improving our power output. However on the next revolution the roles of these cylinders will be reversed with the opposite spark being the wasted one.

Because of the way the system functions, out of one coil both a positive and a negative spark will be produced. For instance if cylinder 1 fires a positive spark then cylinder 4 would fire a negative spark. On earlier types of ignition systems positive sparks were avoided as they take more energy to spark them and they also erode the spark plugs at a greater rate than a negative spark would. With modern ignition systems the power available at the spark plug is far greater than before, so it is not a problem to actually spark the gap, but the problem of spark erosion is still of concern. On a 4 cylinder engine for instance 2 spark plugs will erode more than the other 2. However the sparkplugs have been found to be able to achieve the service interval without failure.

Coil on Plug (C.O.P.)

The latest generation of ignition systems favour the use of coils situated directly on top of the spark plugs, this design allows for the deletion of the HT leads which again absorb spark energy and so reduce the energy available at the spark plugs.

Saab C.D. Ignition

- Saab use a system that is unique to them, it is a capacitor discharge system, it is also a coil on plug system but does not utilise the wasted spark principle.

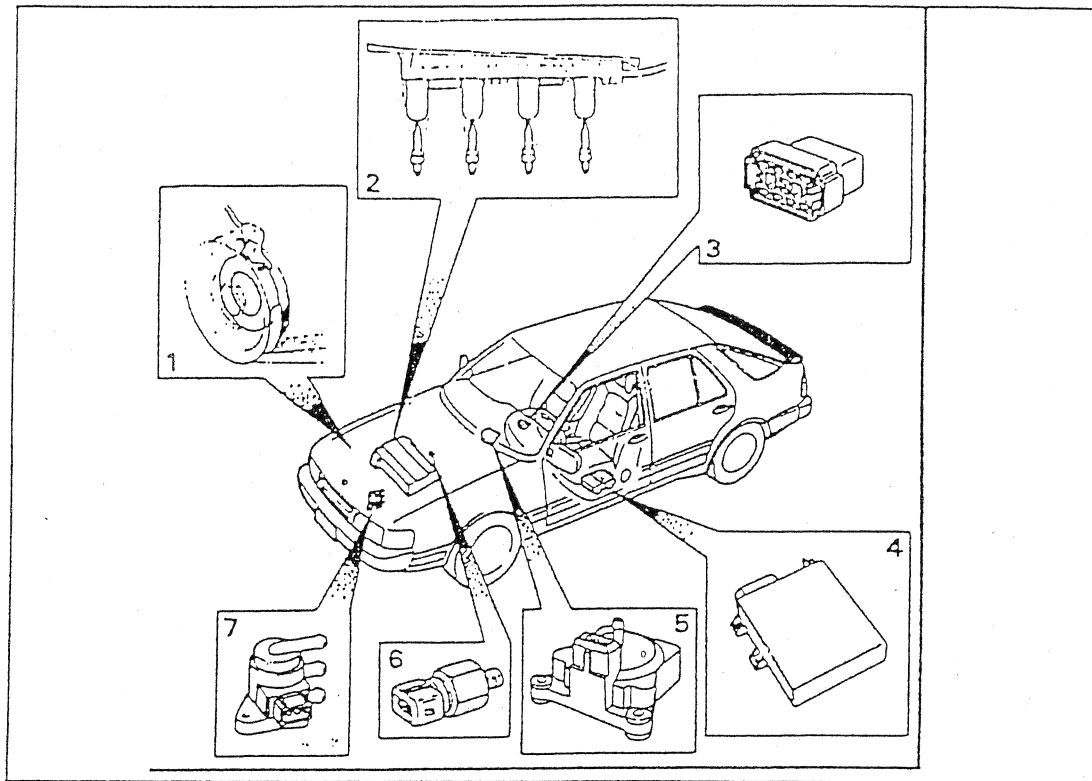


Figure 20 Saab System Layout

The use of capacitor discharge was chosen because of the shortcomings of the standard ignition system, due to the relatively slow coil charge time, energy can leak out through cracks in the distributor cap, dirt on the ignition leads or moisture on the spark plug insulators. These problems can cause misfires or hard starting in cold and damp conditions.

The ignition cartridge is the unique part of the system. It mounts directly onto the cylinder head making contact with the spark plugs. Within the cartridge is the transformer circuit which steps the voltage up from 12 volts to 400 volts where it is stored in capacitors.

The system is controlled by an ECU which receives signals of engine position, speed, temperature, etc. With this information the ECU can decide on the ignition timing and therefore when to supply voltage to the ignition coil.

A Hall effect sensor is employed on the crankshaft pulley to indicate engine position to the ECU. The rotor itself has 3 slots 2 wide slots and 1 narrow slot, the narrow slot is used to indicate to the ECU that the next large slot will be cylinders 1 and 4 approaching TDC, if there is no narrow slot this would indicate that cylinders 2 and 3 were approaching TDC.

On initial start up the system will operate on the wasted spark principle. To avoid unnecessary firing of the spark plugs, the system must determine which cylinder contains the air/fuel mixture which is being compressed ready for ignition.

The method used to achieve this, utilises the fact that, electrons will pass more readily over a hot

gap than a cold gap. If we apply a continuous low voltage (below 400 volts) to the spark plugs the ECU can determine which cylinder out of the pair has just fired by monitoring which cylinder allows more of the electricity to pass through it, within approximately 2 seconds of engine start the ECU has calculated the firing order and so does not fire the wasted sparks.

The system also incorporates an anti flood device. If the engine is cranked without start up for longer than 10 seconds, when the ignition key is released the ECU will send 1000 sparks across each spark plug in 5 seconds, this burns any condensed fuel from the spark plugs.

Note. Because of the way the firing order is calculated the spark plugs fitted to the engine should be of the resistor type only. For ignition diagnostic work for the same reasons extension plug leads must not be fitted. If either of these rules are broken the engine will misfire.