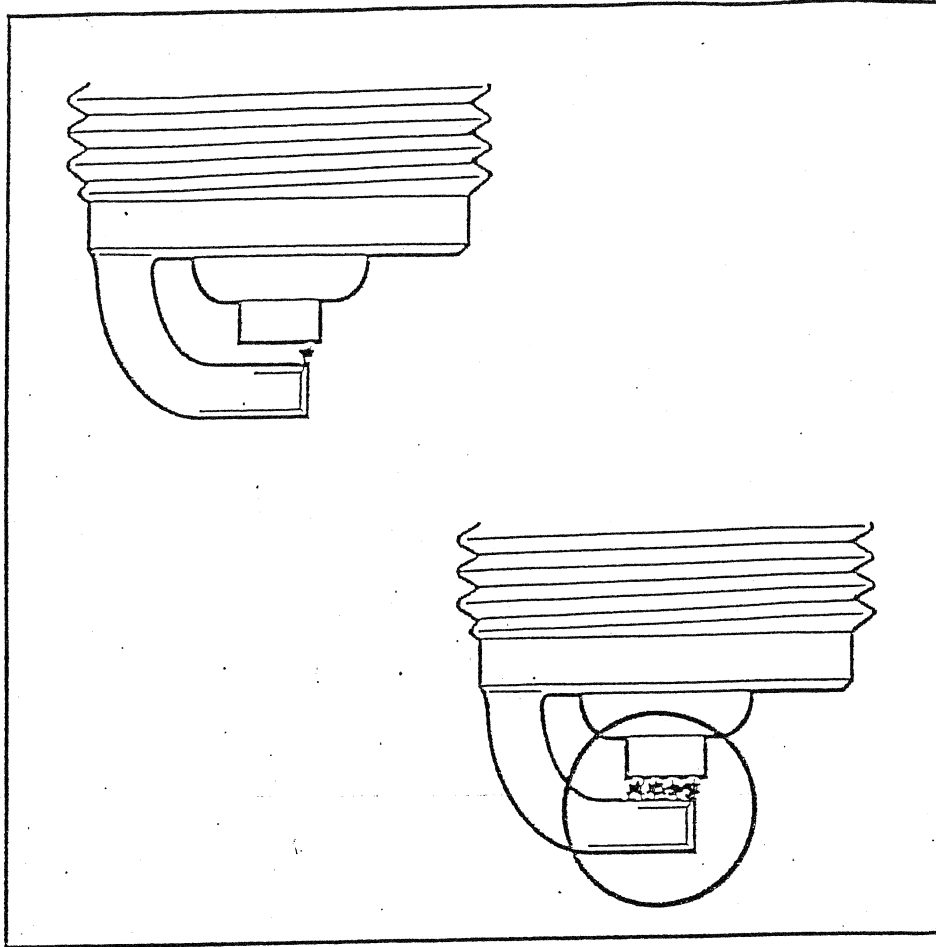


SAAB

DIRECT IGNITION SYSTEM

1: INTRODUCTION TO THE SAAB DIRECT IGNITION (DI) SYSTEM



Saab-Scania presented an entirely new ignition system - the Saab Direct Ignition (DI) system - at the Stockholm Motor Show.

The system is entirely Swedish and has been developed by SAAB.

The new Saab ignition system is based on entirely new principles:

- It is capacitive, which guarantees high voltage without voltage losses.
- It is fully computerised and has no distributor, moving parts or ignition leads.
- The ignition system is totally enclosed in a sealed metal cartridge of patented design.

- Each spark plug is equipped with its own, small high power coil mounted directly on top of the spark plug.

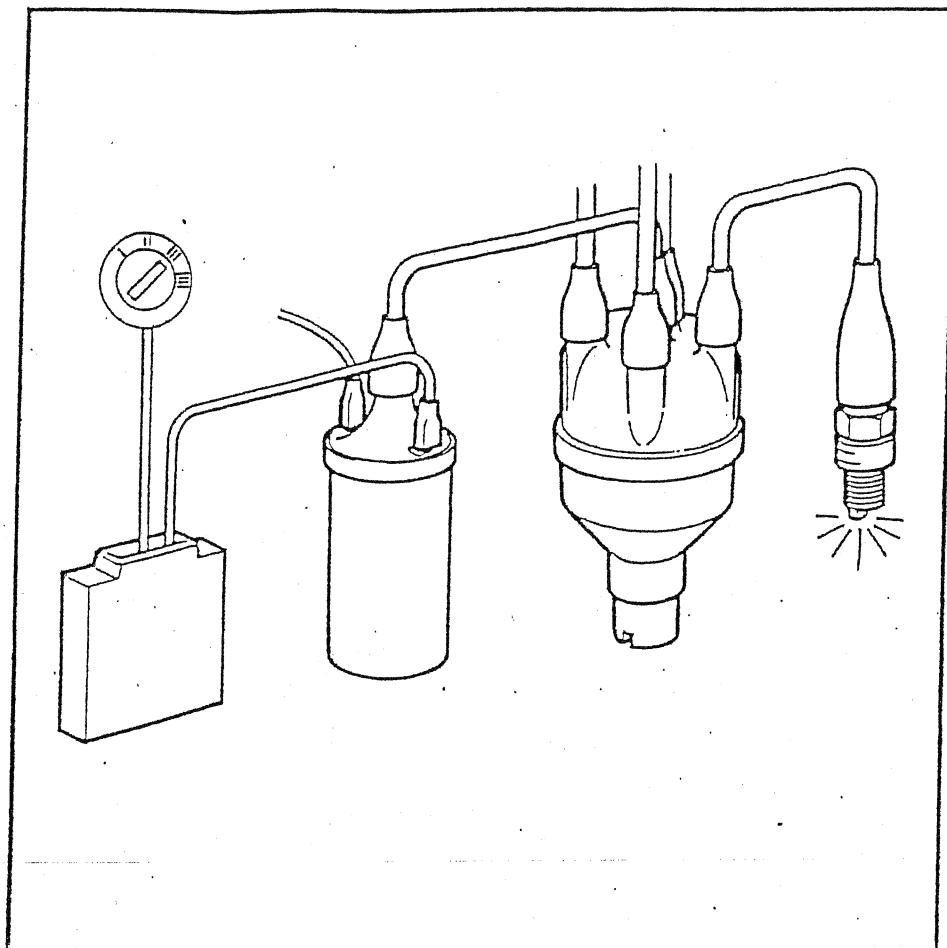
- The ignition pulses are controlled by a sensor on the crankshaft.

- A microprocessor controls the firing of the spark to suit different operating conditions.

The DI system eliminates many of the technical shortcomings of the ignition systems available so far and, in several respects, may provide the basic conditions for future development of petrol engines.

Notes

2: THE TRADITIONAL IGNITION SYSTEM



The ignition systems available so far are mainly of the 'inductive' type.

In an inductive system, a central ignition coil is supplied with the normal battery voltage of 12 Volts and the coil then steps up the voltage to about 25 000 Volts.

The high voltage is supplied from the ignition coil to the distributor, from which it is distributed through separate ignition leads to the various spark plugs.

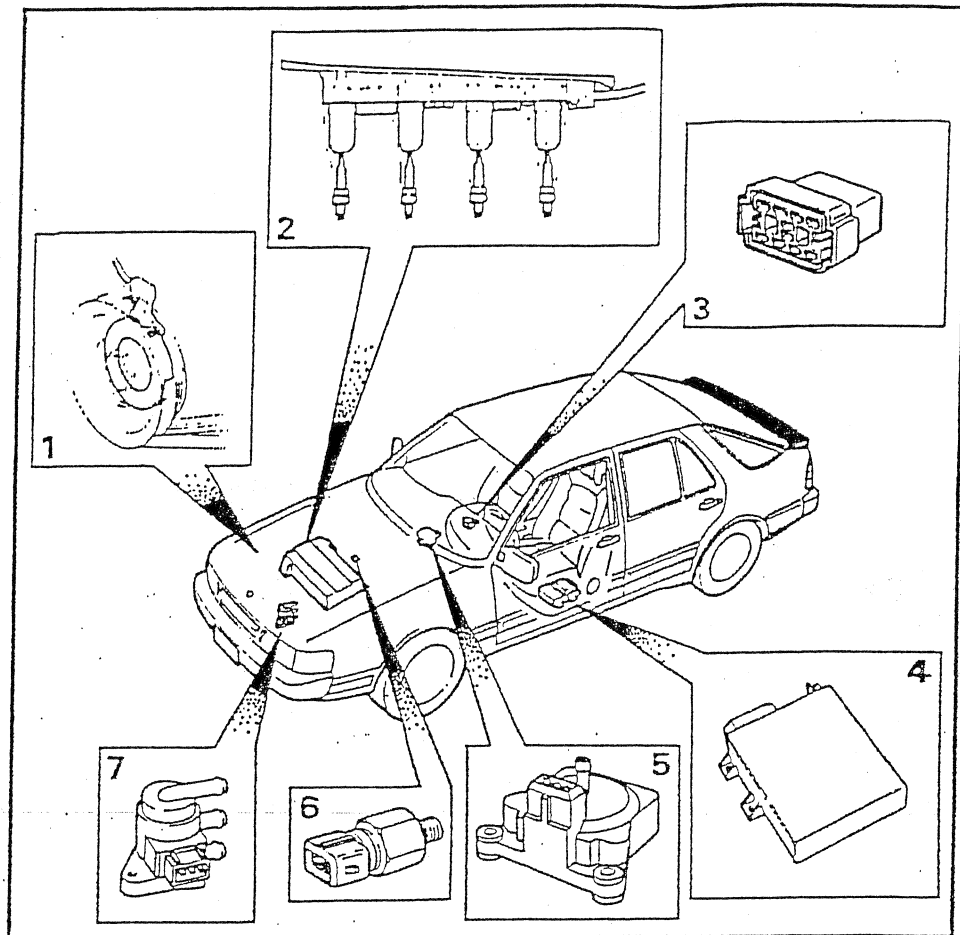
The inductive system has one inherent weakness - it is relatively slow.

In an inductive system, it takes about 20 microseconds to build up the necessary ignition voltage, and this time is long enough for the voltage to 'leak out' through cracks in the distributor cap, dirt on the ignition leads or moisture on the spark plug insulators.

The resulting misfiring in damp weather and when starting from cold are problems that are well known to most motorists.

Notes

3: THE SAAB DI-APC SYSTEM



An entirely new approach on the ignition system was obviously essential before engines could be developed further.

The new DI-APC system is based fundamentally on an already well-known technique - the 'capacitive system'.

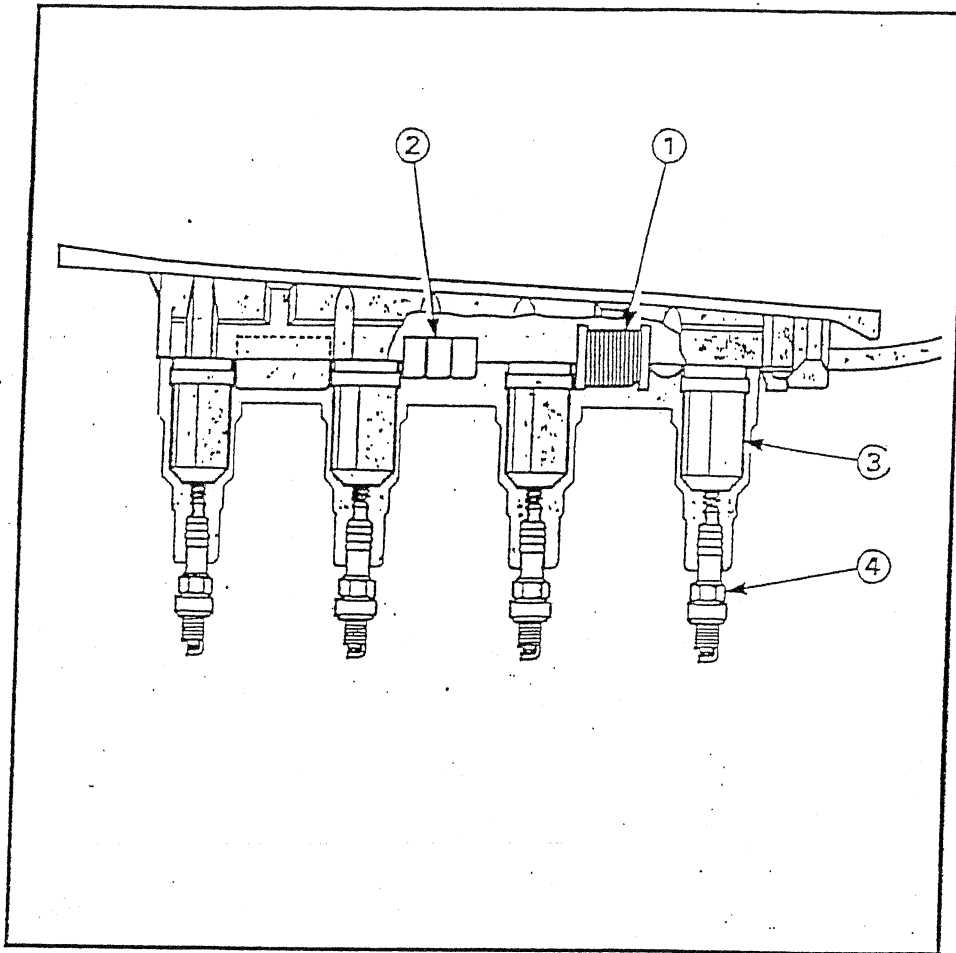
It is the second generation of Direct Ignition systems and features a single electronic control unit which combines the ignition and APC control functions to provide optimum engine timing and boost control under all operating conditions.

Let us consider the system component by component:

- | | |
|---|--------------------|
| 1 | Crankshaft sensor |
| 2 | Ignition cartridge |
| 3 | Test socket |
| 4 | Control unit |
| 5 | Pressure sensor |
| 6 | Knock sensor |
| 7 | Solenoid valve |

Notes

4: IGNITION CARTRIDGE



The ignition cartridge is the unique feature of the DI System.

The cartridge is mounted directly onto the cylinder head and contains a number of interesting components including the transformer (1) which steps up the voltage from 12 Volts to 400 Volts and the capacitor (2) which stores the energy.

The cartridge also contains the ultimate solution to most of the previous problems: the separate ignition coils (3). The DI system has a separate ignition coil for each cylinder - and the coil is mounted directly on the spark plug.

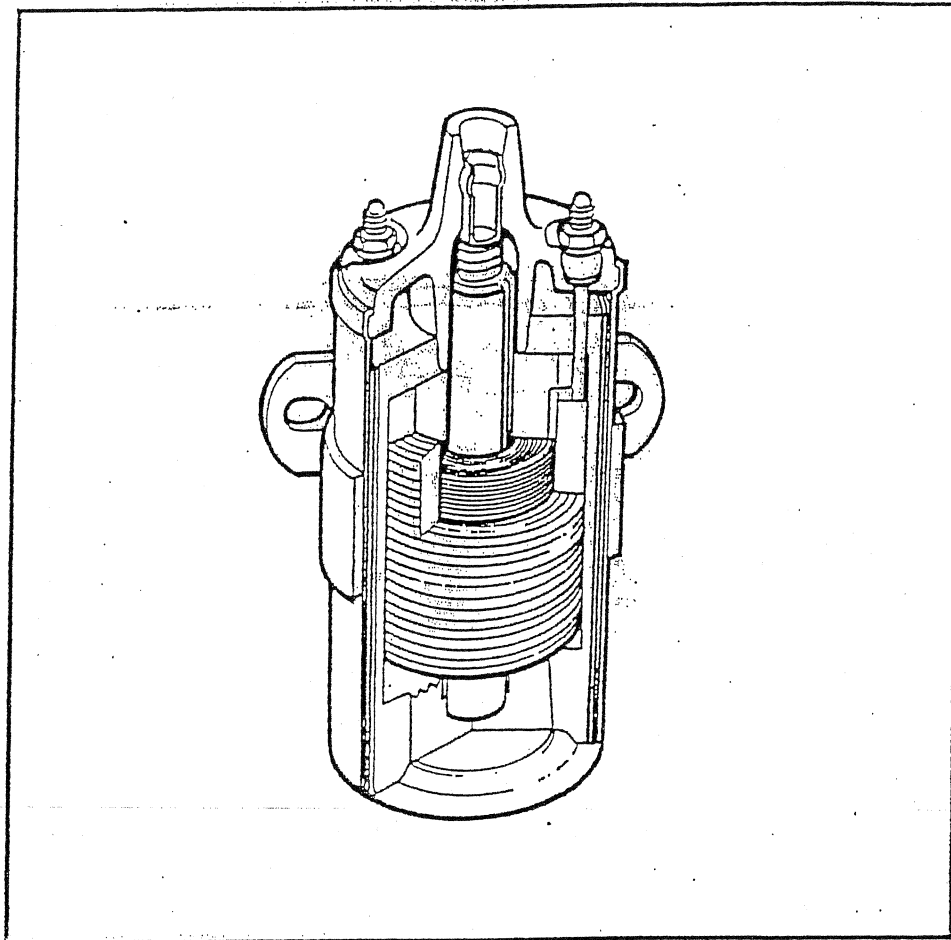
This eliminates all risk of flash-over due to damp and dirty high-tension components and insulators.

The connection between the ignition coil and spark plug (4) is of patented design and makes it easy to fit the entire cartridge to the engine and remove it. As opposed to this, we all know how difficult it can be to disconnect just one ignition lead from a spark plug.

One of the truly important benefits of the DI cartridge is that all the components at voltages above 12 Volts are totally enclosed. The cartridge is made of metal, highly insulated and, together with the cylinder head and camshaft cover, it provides effective shielding to prevent radio interference.

Notes

5: INDUCTIVE SYSTEM IGNITION COIL



The traditional ignition coil is simply a transformer which, interacting with the breaker points, steps up the 12 Volts battery voltage to the high voltage necessary for firing the spark.

In inductive systems, the voltage is stepped up to about 25 000 Volts, although a voltage closer to 40 000 Volts would be necessary to ensure a truly effective spark.

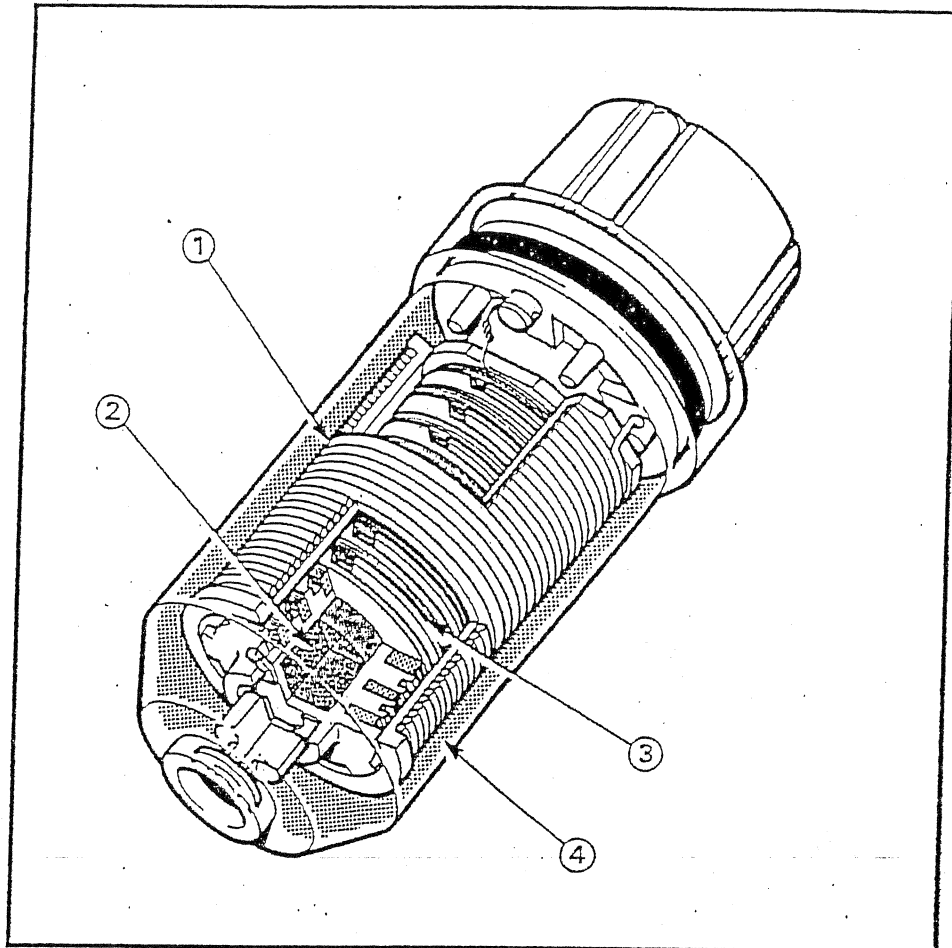
But even stepping-up the voltage from 12 Volts to 25 000 Volts is a major problem. The coil must contain so many turns of copper wire that it takes a relatively long time to build up the spark-firing voltage. Although 'relatively long', this time is still a very short time, being about 20 microseconds - 20 millionths of one second.

What distinguishes the DI system from the inductive system is that the voltage is stepped up in two stages. In the first stage, the 12 Volts battery voltage is stepped up to 400 Volts.

The electrical energy is then stored in a capacitor. To fire the spark, the capacitor is discharged very rapidly through a coil which only needs to step up the voltage from 400 Volts to the final spark-firing voltage.

Notes

6: DIRECT IGNITION COIL



The coil of the DI system has a low tension winding (1) supplied with a voltage of 400 Volts. The high tension winding (3) is wound around the iron core (2). This high tension winding has fewer turns than the corresponding winding in an inductive system, and it therefore takes no more than 1 microsecond to build up the spark-firing voltage.

An additional benefit is that the spark-firing voltage of 40 000 Volts is appreciably higher than that in an inductive system, which results in much more reliable firing under any operating conditions. But more about this later.

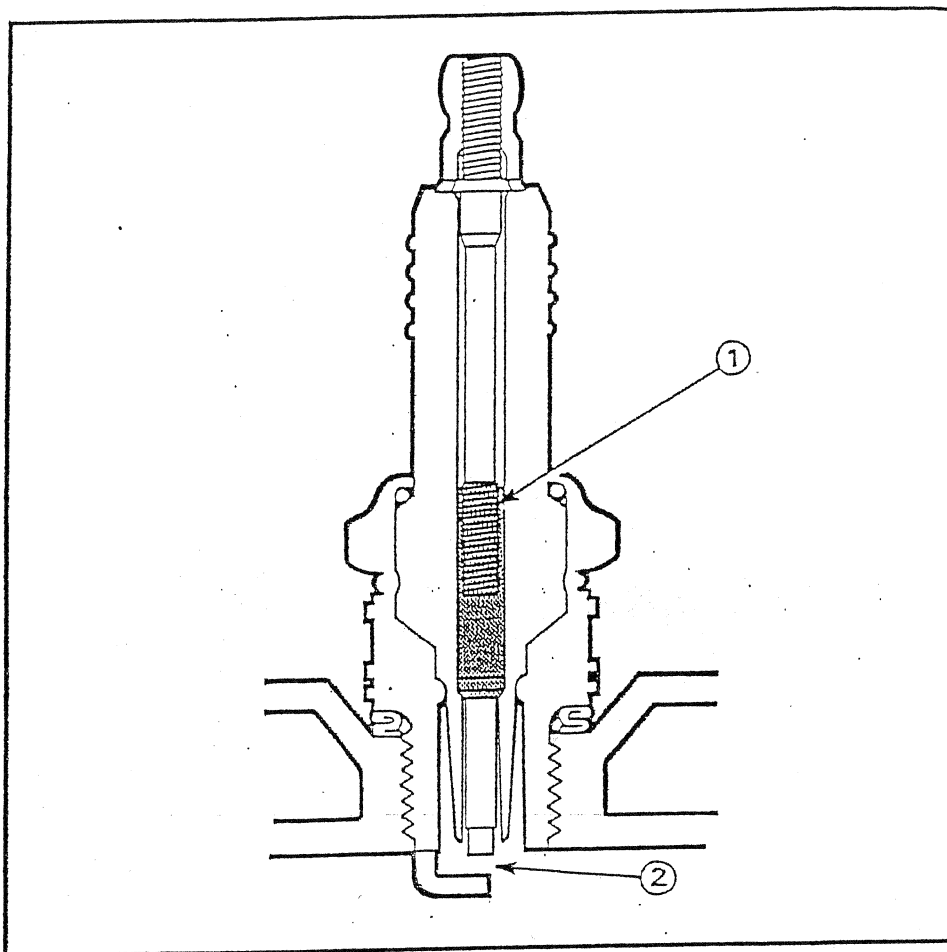
By providing intermediate storage of electrical energy in the capacitor, the spark-voltage can be achieved in 1/20th of the time.

So even if the spark plug insulators are dirty or damp, the current will simply not have sufficient time to 'leak out', and a very powerful spark will be fired where it should be - between the spark plug electrodes.

The ignition coil is filled with cooling oil (4) under vacuum to 75% of its volume. This enables the oil to expand as it warms up. The coils can be replaced individually.

Notes

7: SPARK PLUG



It is no easy task to design a spark plug with the correct working temperature - particularly if it is expected to work efficiently both in city traffic and at high speeds on the motorway.

The problem is accentuated if the engine is run on unleaded petrol, with alcohol additives or if it is equipped with a catalytic converter (the catalyst will soon be destroyed if the engine misfires).

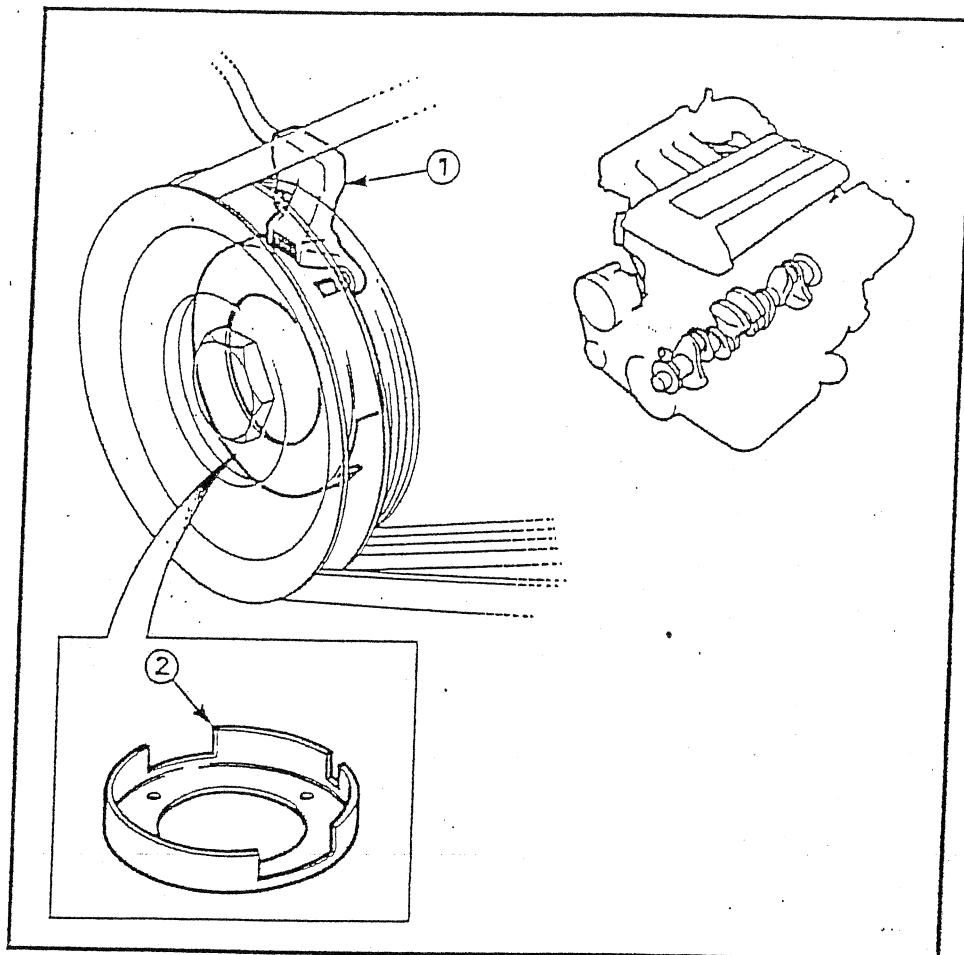
The DI system offers the solution to this problem too: You are perfectly free to use a cold, reliable spark plug, since the system has ample capacity to ensure that an effective spark will be fired even if the insulator is wet and dirty.

With the present ignition system, the electrode gap (2) in the spark plug must be maintained between 0.6 and 0.8 mm. The DI system allows for a very large gap - between 0.9 and 1.5 mm. As a result, the service life of the spark plugs is many times longer.

The spark plugs are of resistor type (1), in order to minimise interference with the DI electronic control unit. They also minimise interference with the radio. The DI system uses the electrode gap to sense whether the fuel/air mixture in the cylinder has been fired. How this is used for synchronising the DI system with the engine will be described later.

Notes

8: CRANKSHAFT SENSOR



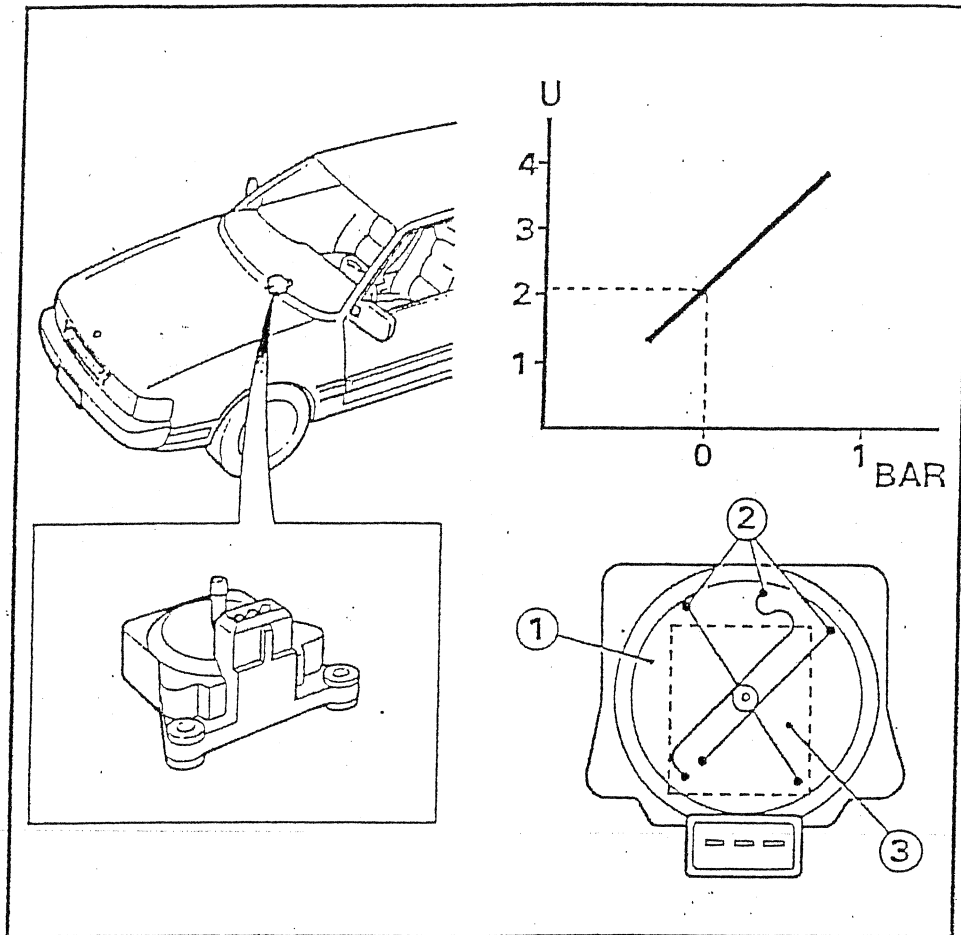
The DI system has no conventional distributor. As described earlier, the DI system uses the crankshaft to trigger the firing of the spark at exactly the right instant. This is done by a Hall sensor (1) and a slotted rotor (2), which ensures extreme accuracy. The sensor has an accuracy of ± 0.5 degrees of crankshaft rotation, as compared to an accuracy of ± 3 degrees when the spark is fired by a conventional distributor. So the accuracy of the DI system is six times better.

Furthermore - and this is one of the most important features - the ignition need never be adjusted throughout the entire lifespan of the engine. In practice, the system is so accurate that no adjustment is necessary even when the engine is first assembled.

In addition to providing information on the crankshaft position, the Hall sensor also monitors the pistons which are at the top dead centre (TDC), and the engine speed. But we'll return to this later.

Notes

9: PRESSURE SENSOR



The pressure sensor is common to the DI system and the APC system. It provides these systems with information about the engine load by measuring the pressure in the intake manifold.

The information is in the form of a linear voltage between 0 and 5 Volts, depending on the actual pressure in the intake manifold (see graph).

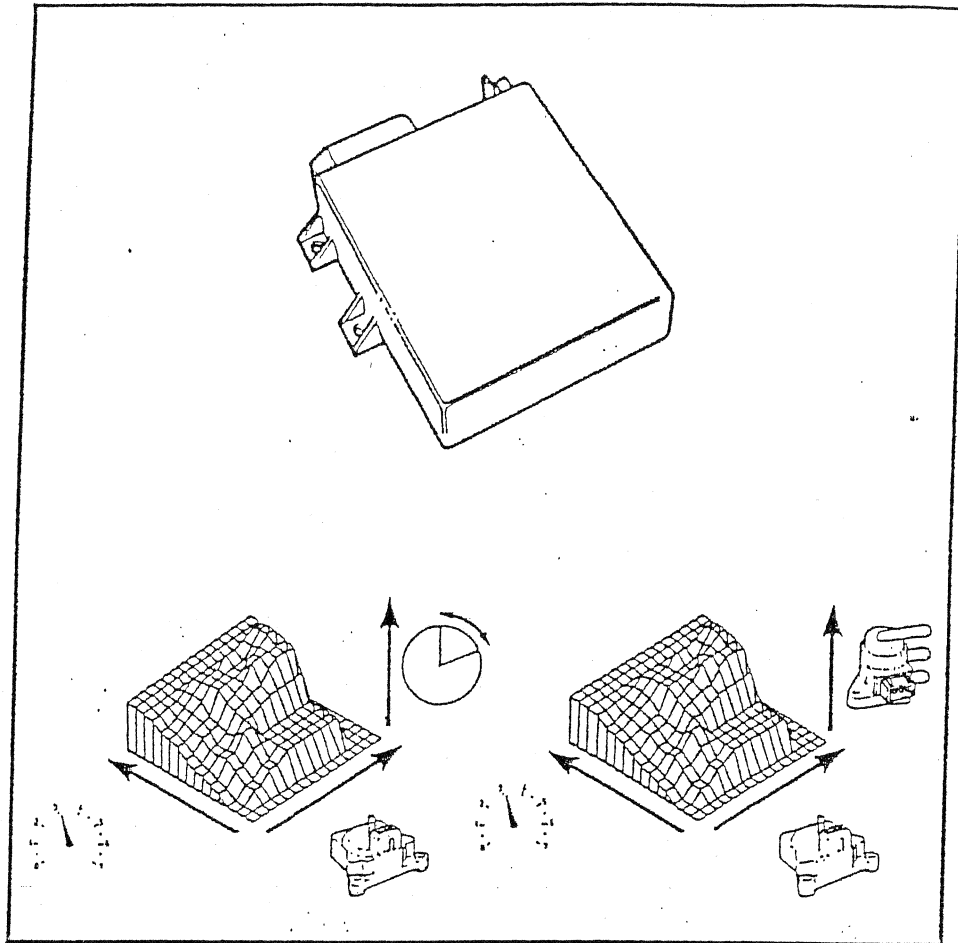
The voltage at atmospheric pressure (0 Bar) is 2.2 Volts.

The sensor consists of a porcelain disc (1) with four thick film resistors (2) mounted on it and an integrated circuit (3). As different pressures are applied to the sensor the disc deflects and stretches the resistors mounted on it, causing their resistance to change.

The integrated circuit applies a voltage across the resistors and measures any changes in this voltage caused by the change in resistance due any deflection of the disc. It then uses this signal to generate an output voltage signal.

Notes

10: CONTROL UNIT



Information from the crankshaft sensor, pressure sensor, knock sensor, cruise control, fuel injection system, brake pedal and ignition cassette is processed in the control unit which is mounted under the left-hand front seat.

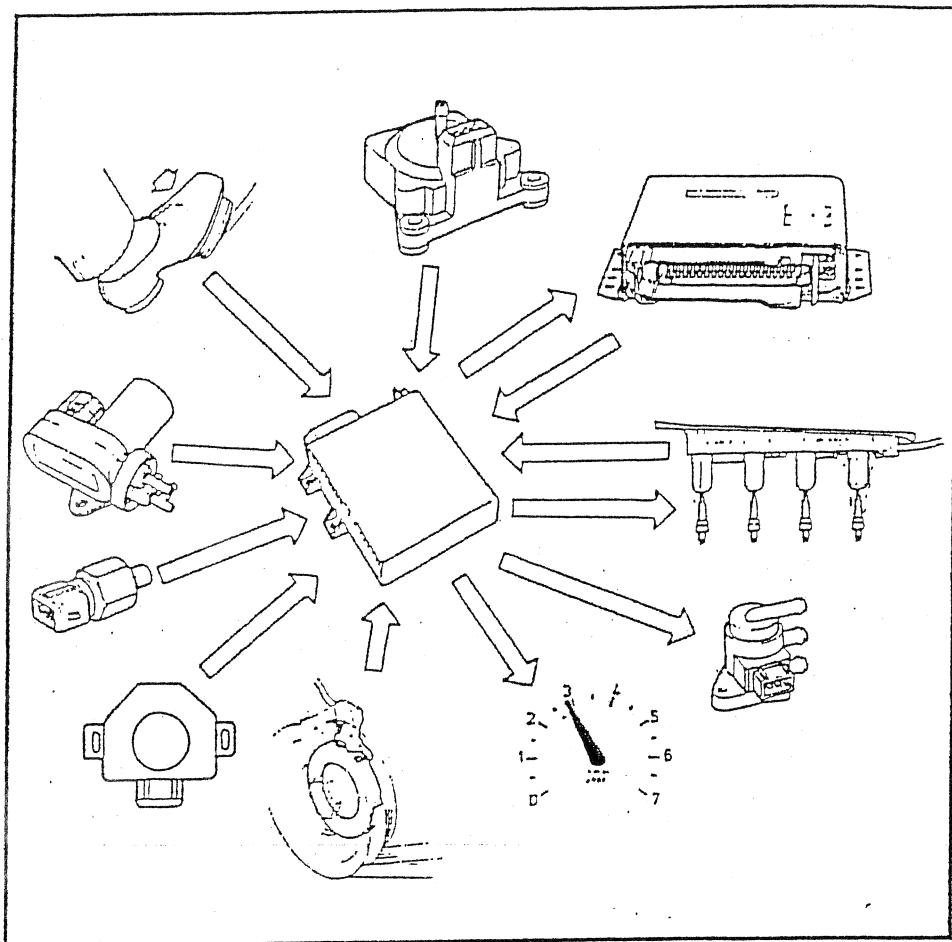
By programming the microprocessor for a wide variety of conceivable operating conditions, the ignition spark firing and the boost pressure will be controlled extremely accurately under a wide variety of motoring conditions.

Compare the 'landscape' graph which in a sense has been programmed into the processor in the control unit.

The control unit incorporates a self-diagnostic function which scans the system every time the engine is started and while it is running. Any fault in the system is stored in the memory, which can then be read by Saab's new ISAT test instrument.

Notes

11: CONTROL SIGNALS



The electronic control unit is the brain of the DI-APC system, receiving information from many sources, comparing the information with pre-programmed data and issuing control signals to system components.

It receives information from:

Crankshaft sensor - crankshaft position and engine speed.

Pressure sensor - engine load.

Ignition cartridge - cylinder in which combustion is taking place.

Knock sensor - presence of engine knocking.

Throttle position switch - full throttle condition.

Cruise control - engaged.

Brakes - engaged.

Fuel system control unit - deceleration and specific load conditions.

The control unit processes the information, and its programs control the spark-firing instant, boost pressure and fault warning.

The electronic control unit issues signals to:

Ignition cassette - ignition timing

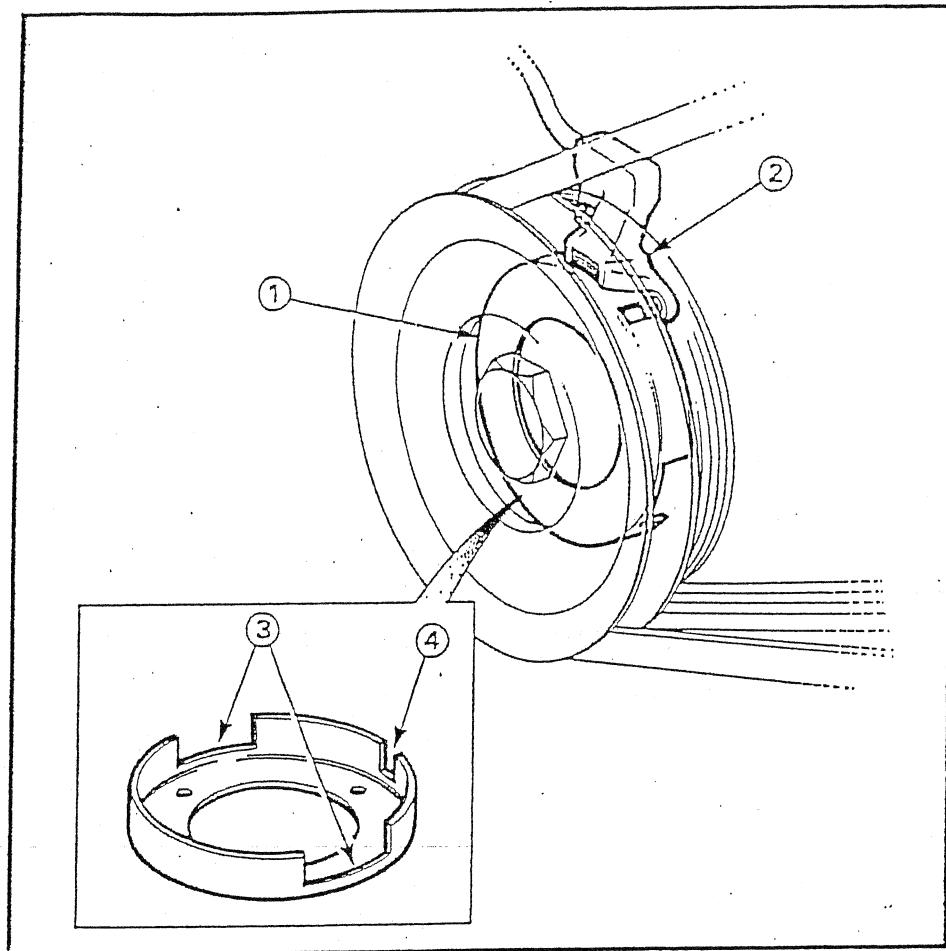
Solenoid valve - boost pressure control

Tachometer - engine speed

Fuel system electronic control unit - pre-ignition.

Notes

12: CRANKSHAFT SENSOR SIGNAL.



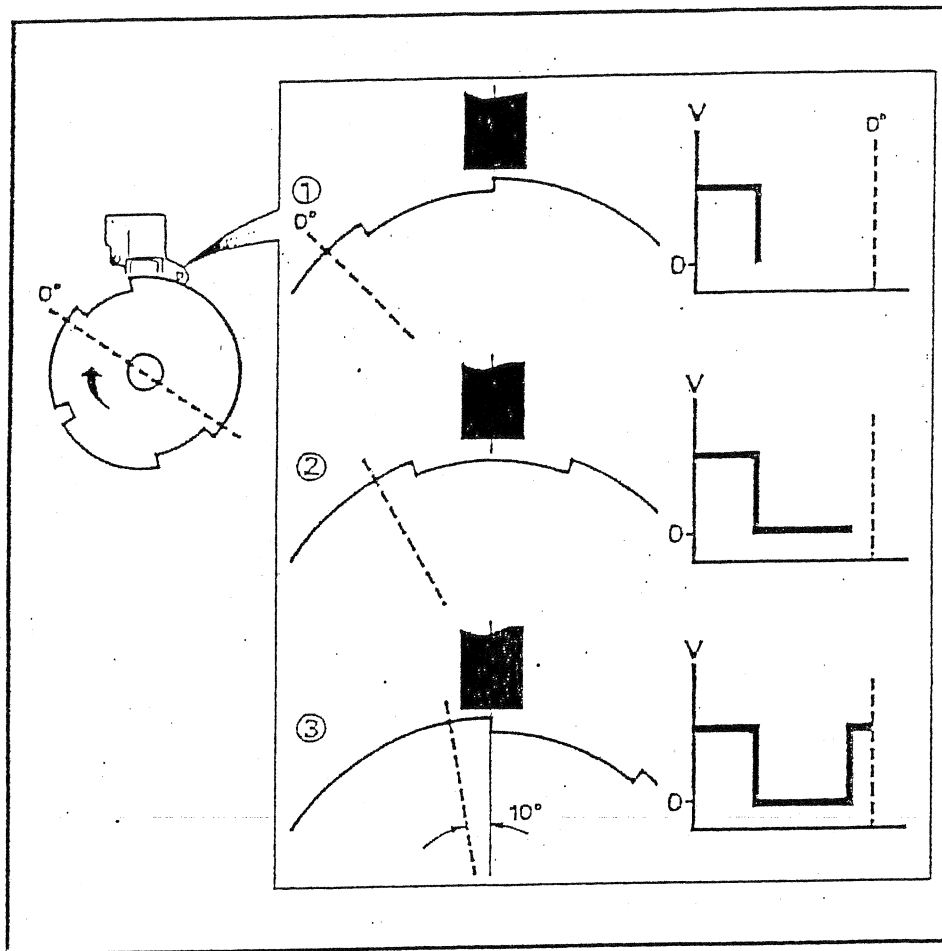
A slotted rotor (1) is mounted behind the engine belt pulley and rotates in the gap of a Hall sensor (2).

The slotted rotor has three slots, two of which are wide and one is narrow. The wide slots (3) are orientated so that one of them provides the piston position signal for cylinders 1 and 4, and the other, the piston position signal for cylinders 2 and 3. The third, narrower slot (4) is provided to enable the Hall sensor to distinguish between the two wider slots.

When the slotted rotor is rotating, the narrower slot (4) will provide an indication before the wide slot (3) passes the Hall sensor, whereas no such indication will be provided before the other wide slot (3) passes the sensor. This enables the control unit to distinguish between the signals for cylinder pairs 1-4 and 2-3.

Notes

13: SLOT SIGNAL (A)



When a slot passes the Hall sensor, it gives rise to a signal in the form of a change in voltage. Let us see what happens when the slot for cylinder pair 2-3 passes the Hall sensor.

When the solid part of the slotted rotor is in the Hall sensor gap, the voltage across the gap is a maximum, whereas when the slot (i.e. air) is in the gap, the voltage is zero.

Figure 1

When the slotted rotor rotates to the position shown in the figure, the slot is on its way into the gap, and when the right-hand edge of the slot is at the centre of the Hall sensor gap, the voltage will drop instantaneously to zero as shown in the graph to the right.

This position corresponds to 45 degrees of crankshaft rotation before the top dead centre position for cylinders 2-3. This is the signal from which the control unit calculates the ignition timing for different operating conditions.

Notes

13: SLOT SIGNAL (B)

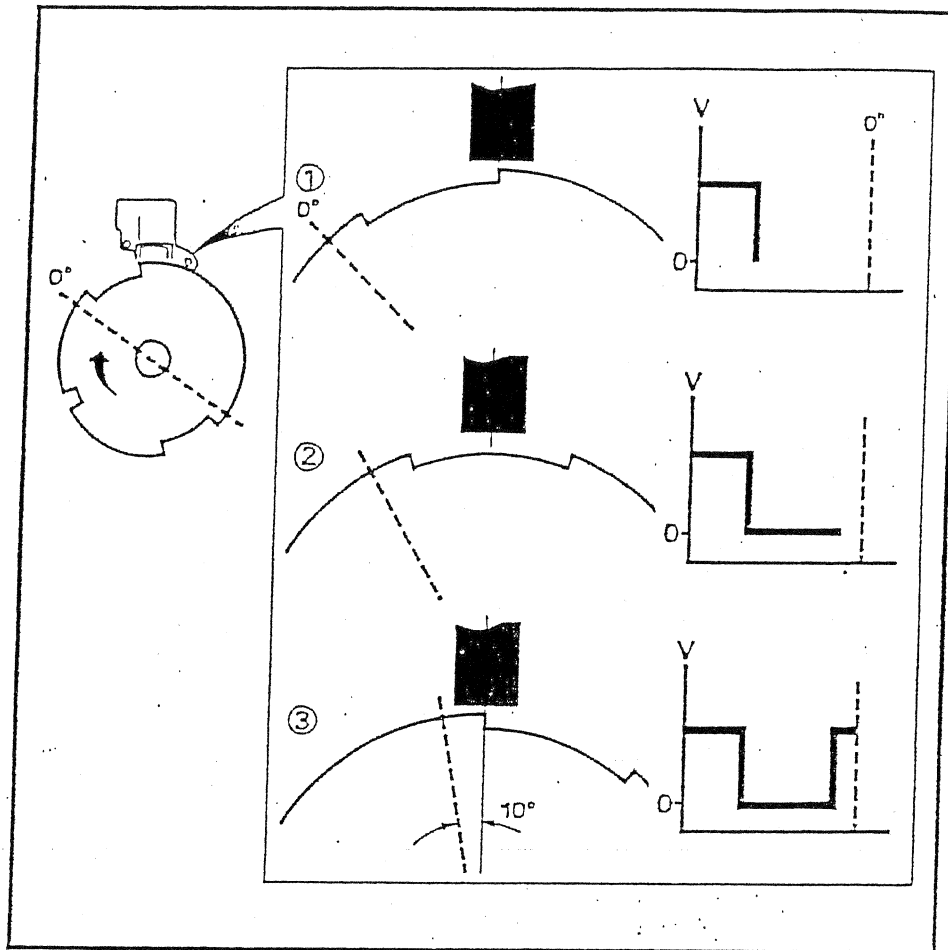


Figure 2

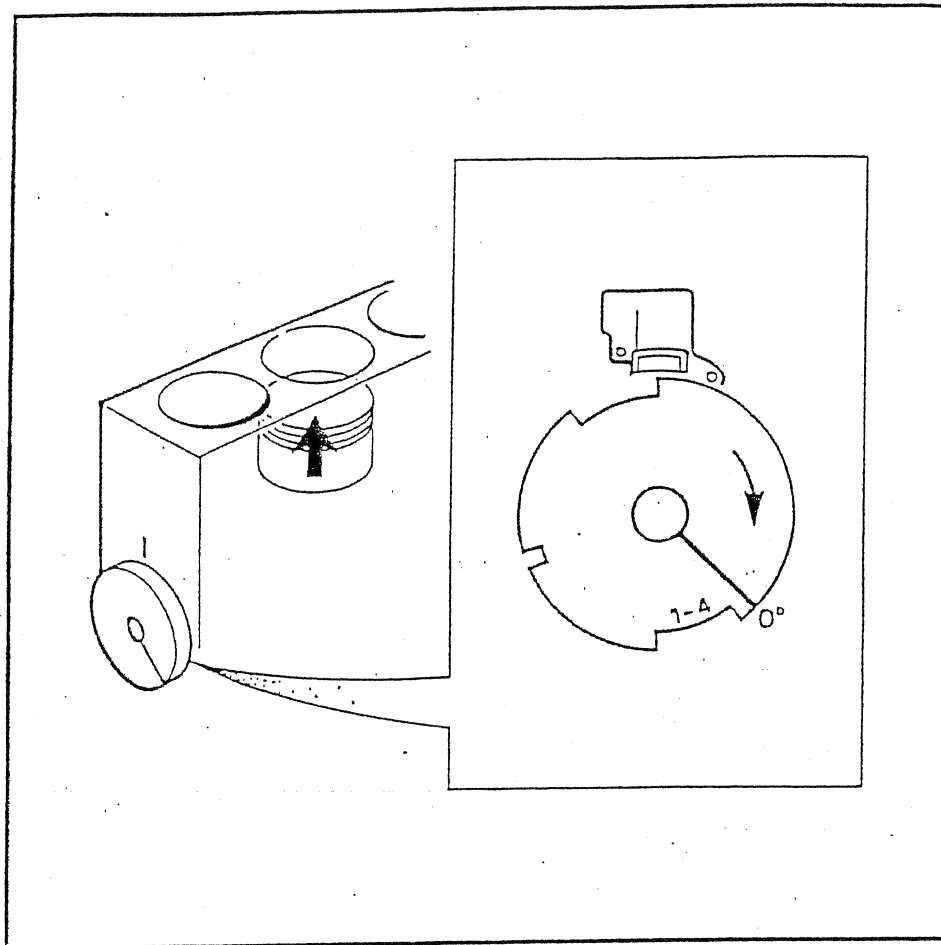
Only the rotor slot is in the the Hall sensor gap and the voltage is zero as shown in the graph. The spark may be fired at any time, depending on the calculations carried out in the control unit, based on the engine operating conditions and starting from the edge at 45° BTDC.

Figure 3

The slot is on its way out of the Hall sensor gap. When the left-hand edge is in the centre of the gap, the voltage will revert instantaneously to the maximum value. The pistons in cylinders 2 and 3 are now at 10° BTDC. If the engine is being turned by the starter motor (below 850 r/min), the DI system will give a fixed ignition point at 10° BTDC.

Notes

14: CRANKSHAFT POSITION AND ENGINE SPEED SIGNAL



The signal from the slotted rotor is used to provide the control unit with three items of information. In the first place, exact information on when the spark should be fired, as described in the previous figure.

Let us now see how the slotted rotor enables the control unit to identify the pistons that are at the top dead centre and how we measure the engine speed.

Crankshaft Position

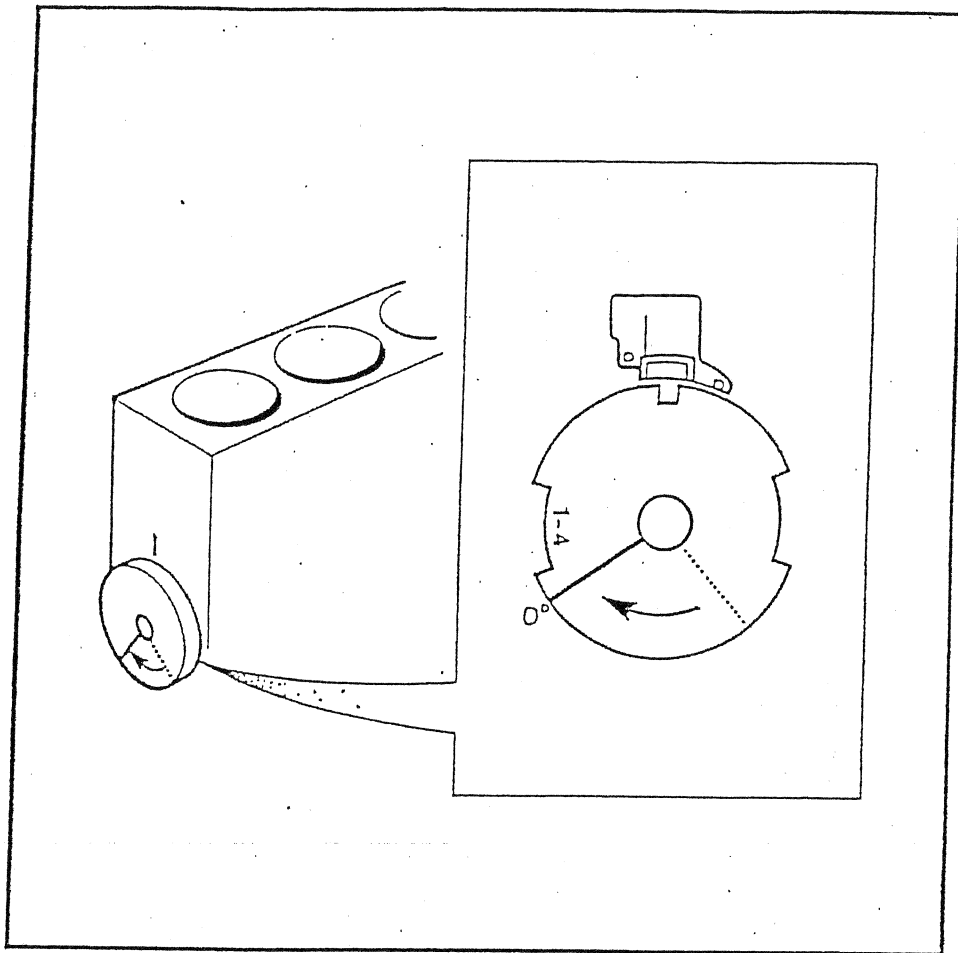
Let us consider the signals needed by the control unit to identify whether the pistons in cylinders 1-4 or those in cylinders 2-3 are at the top dead centre.

Let us start with the pistons in the position in which the slotted rotor must rotate through 225° before pistons 1 and 4 are at the top dead centre. The Hall sensor takes several readings during these 225°.

The figure shows that the Hall sensor records that a wide slot is passing.

Notes

15: CRANKSHAFT POSITION SIGNAL

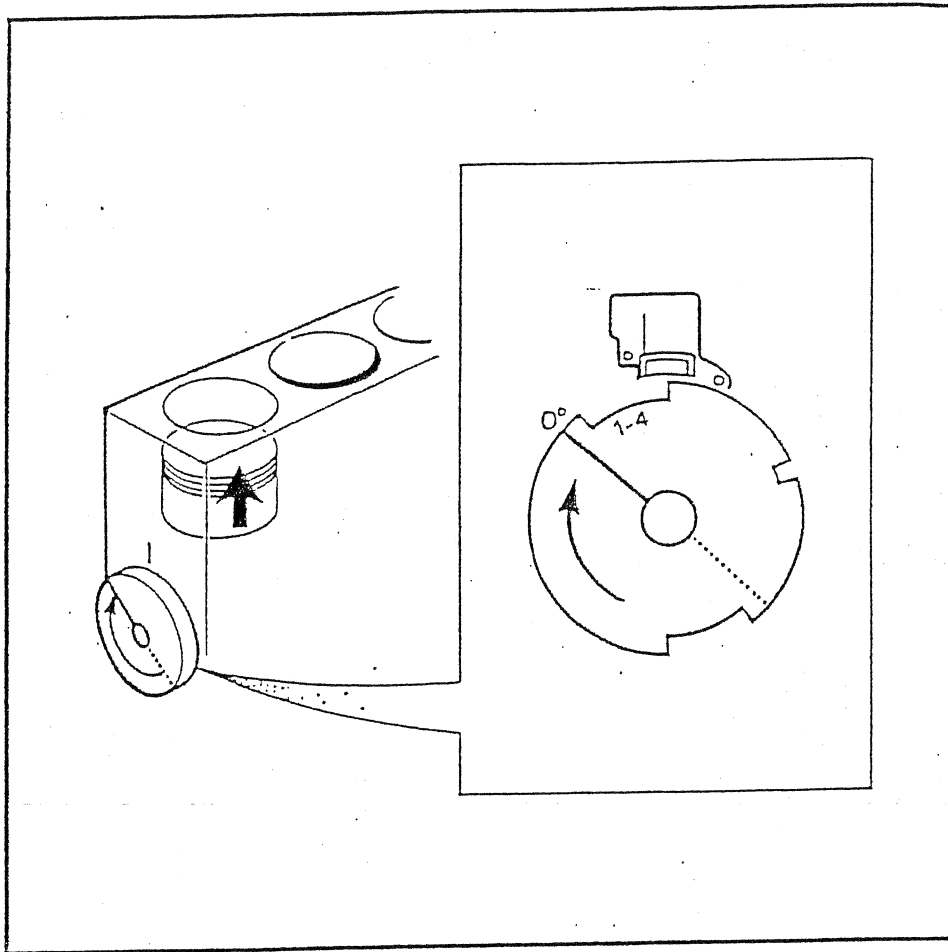


The slotted rotor has now rotated through about 90° and the Hall sensor records a narrow slot.

The wide slot + narrow slot signals tell the control unit that the next slot will be for pistons 1 and 4.

Notes

16: CRANKSHAFT POSITION SIGNAL

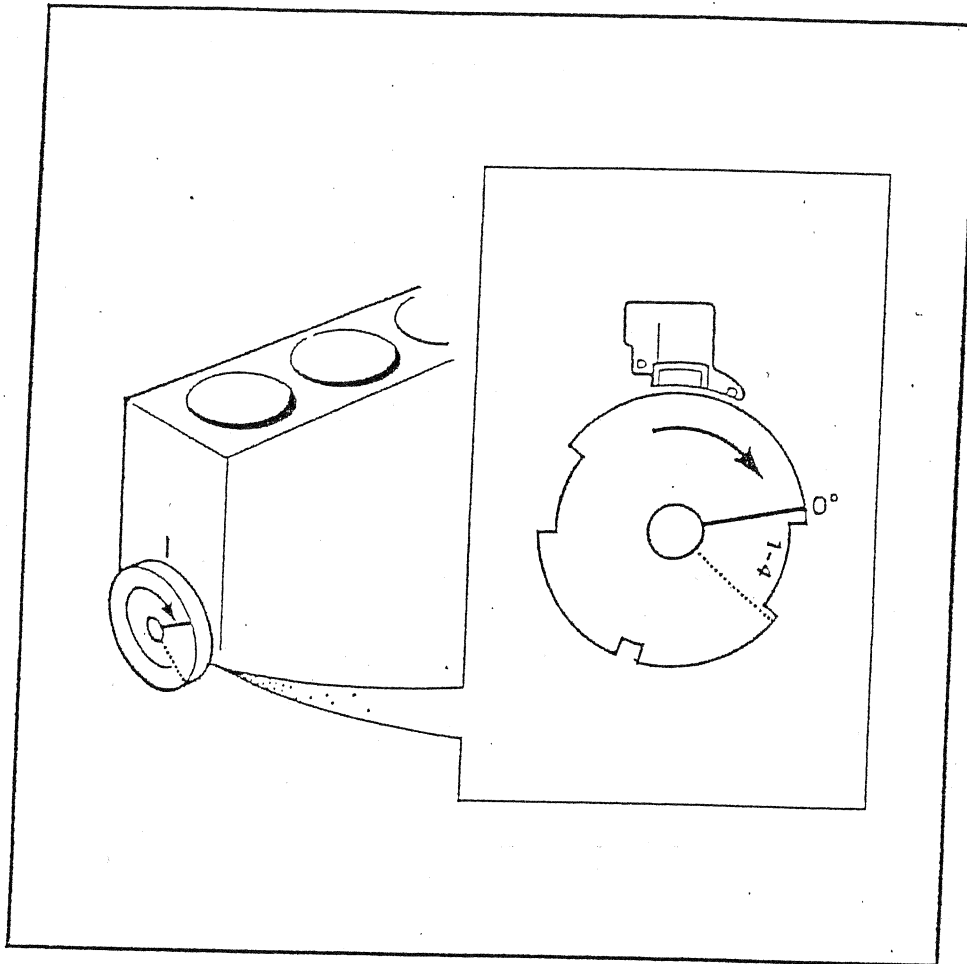


When the slot for pistons 1 and 4 enters the Hall sensor gap, the Hall sensor voltage will drop to zero and the control unit will know that this is the ignition point for cylinders 1 and 4.

At the same time as the slot starts the spark-firing for pistons 1 and 4, the Hall sensor determines that it is a wide slot which is passing. This information is necessary for identifying the piston pair which will be on its way up in the cylinders on the next firing occasion.

Notes

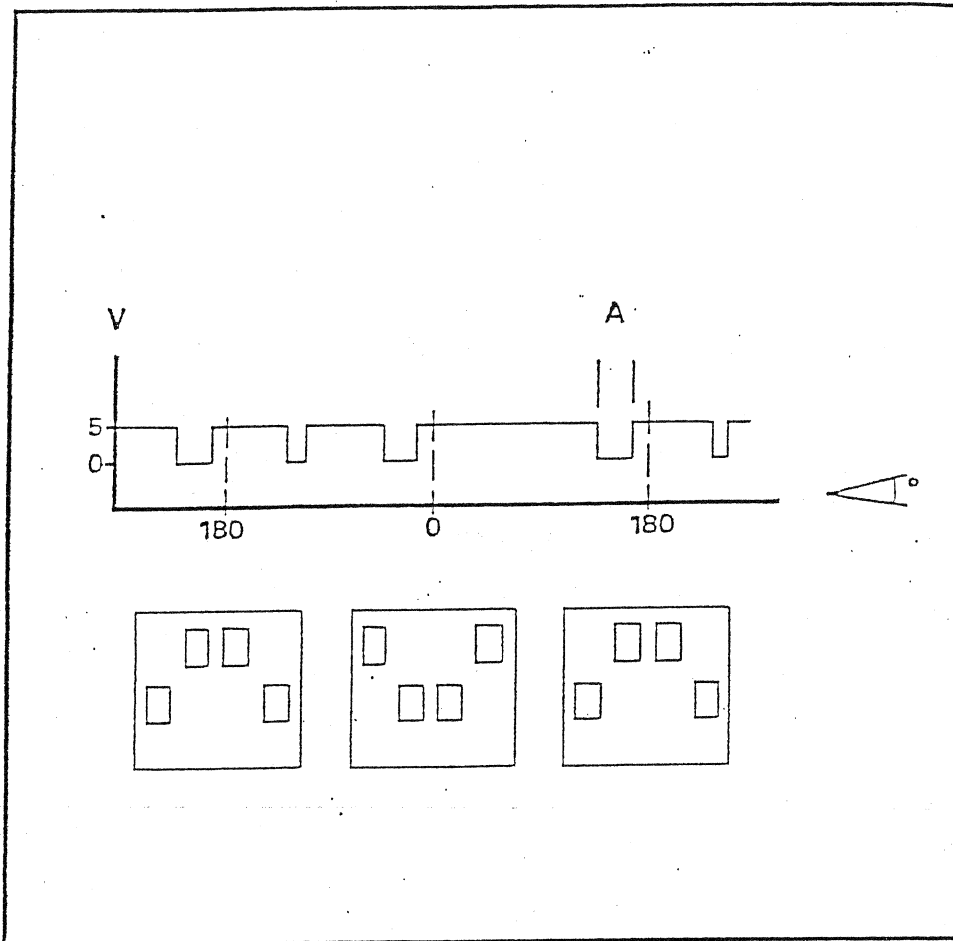
17: CRANKSHAFT POSITION SIGNAL



The slotted rotor has now rotated through a further quarter of a revolution. On the previous occasion when the area between the two wide slots was passing the Hall sensor, the sensor recorded a narrow slot. But not this time. The wide slot + no slot signal tells the control unit that the next slot will be the signal for pistons 2 and 3.

Notes

18: CRANKSHAFT POSITION AND ENGINE SPEED SIGNAL



In summary, the Hall sensor voltage as seen on an oscilloscope screen would be as illustrated in the figure.

The top dead centres of the pistons are shown below the graph, and 0° is the top dead centre for pistons 1 and 4, exactly as on the engine flywheel in reality.

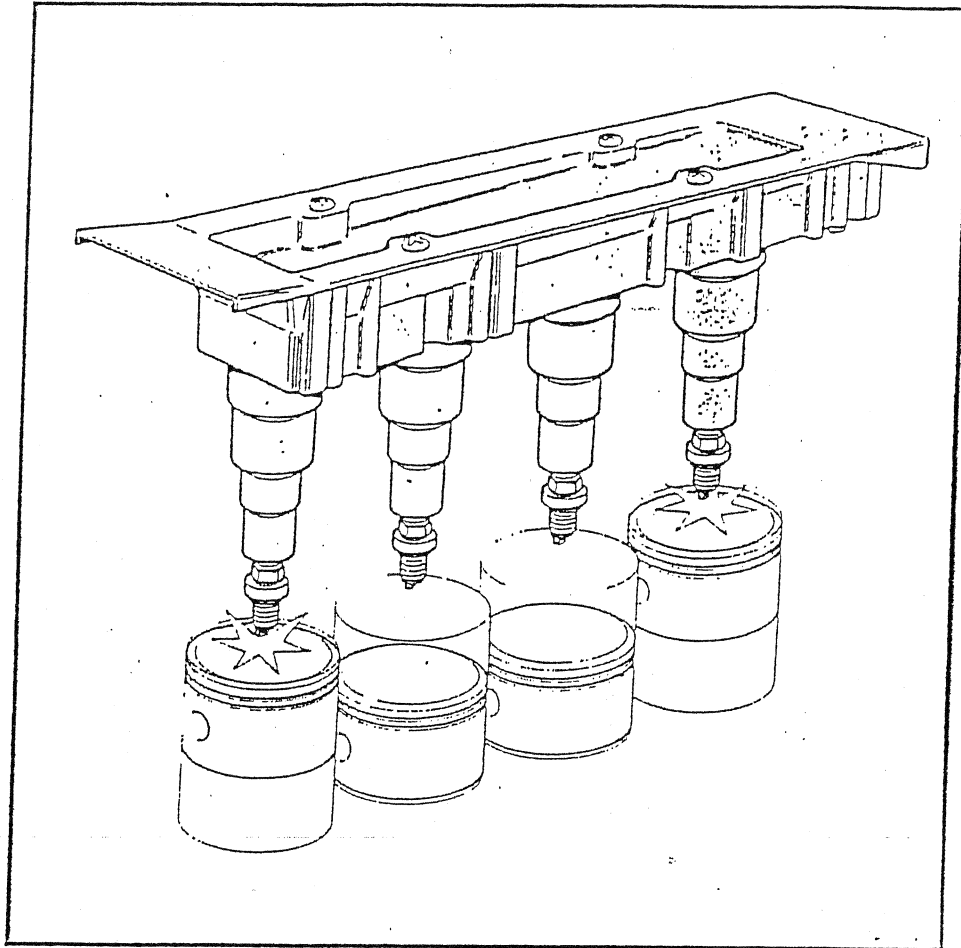
It will be noted that the curve is similar to a 'straightened-out' slotted rotor, the slots corresponding to the 'gaps' in the voltage curve. From left to right, the voltage corresponds to the rotation of the slotted rotor.

Starting at any point along the curve and moving through one revolution, we will always record two large voltage gaps, a small voltage gap and a long distance without a voltage gap. The sequential order will vary depending on where we have started, and this enables the control unit to determine the positions of the pistons and the crankshaft.

To determine engine speed, the control unit measures the time it takes for the wide gap at 'A' to pass the hall sensor.

Notes

19: CRANKSHAFT POSITION SIGNAL



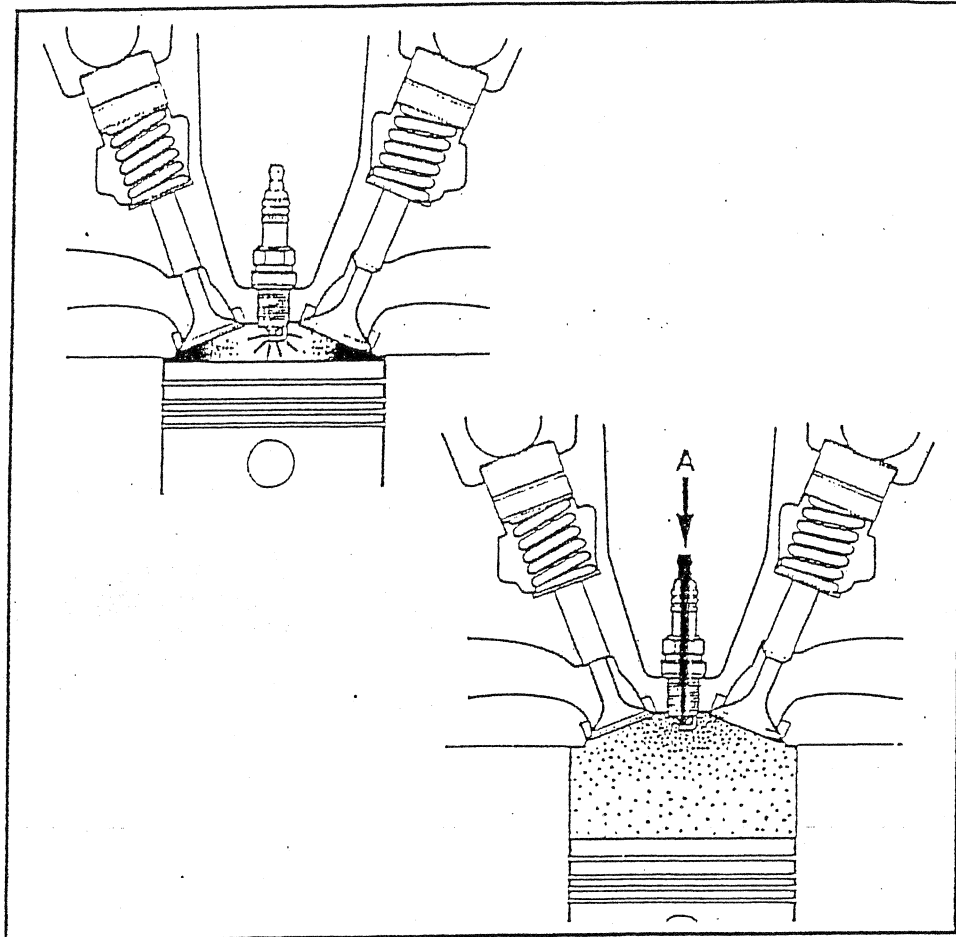
We can now identify the two pistons that are on their way up to the top dead centre. But how does the system know which of the two cylinders contains compressed fuel/air mixture which is ready for firing?

Firing an unnecessary spark across the electrodes of a spark plug will only shorten the useful life of the spark plug.

The system doesn't know this yet. So when the engine is started, the ignition system will fire two sparks at the same time, i.e. one spark in each cylinder in which the piston is on its way up to the top dead centre. Ignition will then take place in the cylinder containing compressed fuel/air mixture, but the spark fired in the other cylinder will be of no use, since the piston is on the exhaust stroke.

Notes

20: COMBUSTION (SYNCHRONISATION) SIGNAL



To avoid unnecessary firing of the spark, the system must be able to determine which of the two cylinders contains fuel/air mixture which must be fired and which must not.

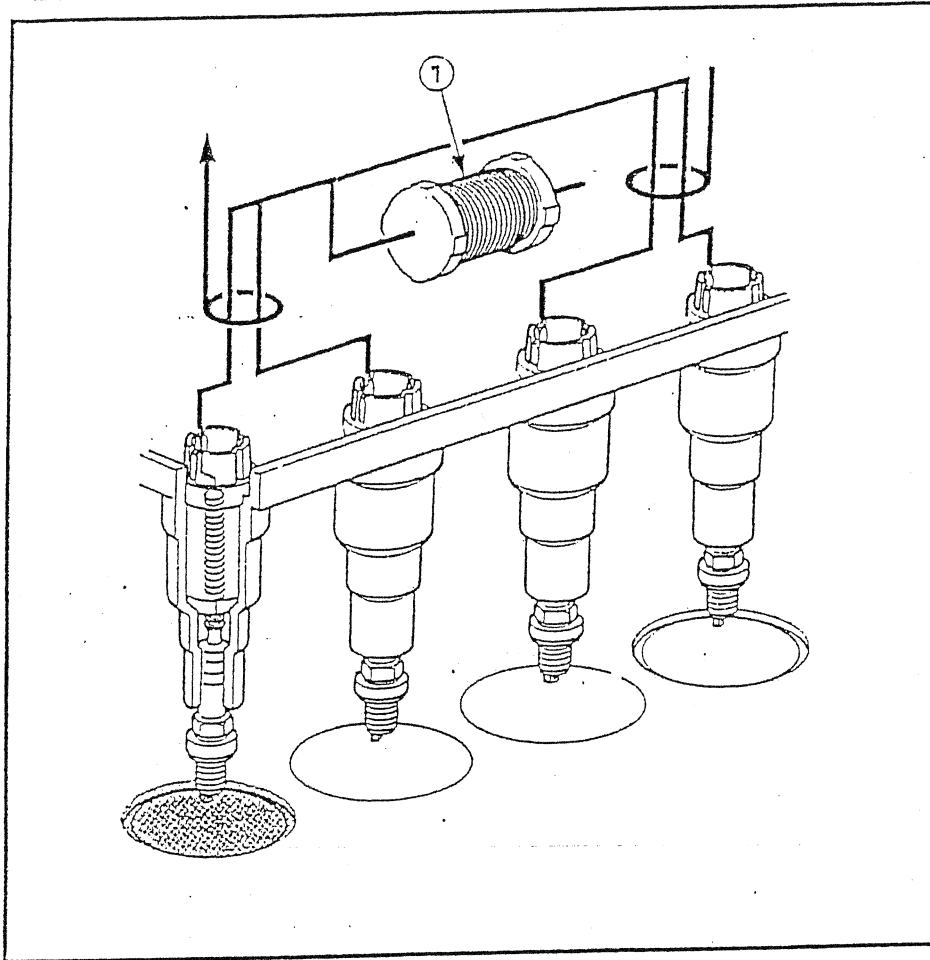
To do this, the DI system employs a method which utilises the ionisation occurring during combustion. The method is based on the principle that electric current (A) flows more easily if the spark plug gap is at high temperature than if it is at low temperature. This is because small particles (ions) are in violent movement at high temperature and can transport electrical charges more easily between the spark plug electrodes. As a result, a weak current flows across the gap during combustion.

If we apply a continuous low voltage (below 400 Volts) to all spark plugs, we can determine the plug at which combustion has started by determining at which of the current is flowing.

This signal is used by the control unit to synchronise the signal it receives from the crankshaft sensor with the ignition timing.

Notes

21: COMBUSTION SIGNAL - NUMBER 1 CYLINDER



The ignition cartridge contains a transformer (1) which steps up the voltage from 12 Volts to 400 Volts. The system applies part of this voltage continuously to the four spark plugs via a high tension winding.

When the pistons of cylinders 1 and 4 are approaching top dead centre, the system will fire sparks in both cylinders. In this case, cylinder 1 will fire, since the piston is on the compression stroke.

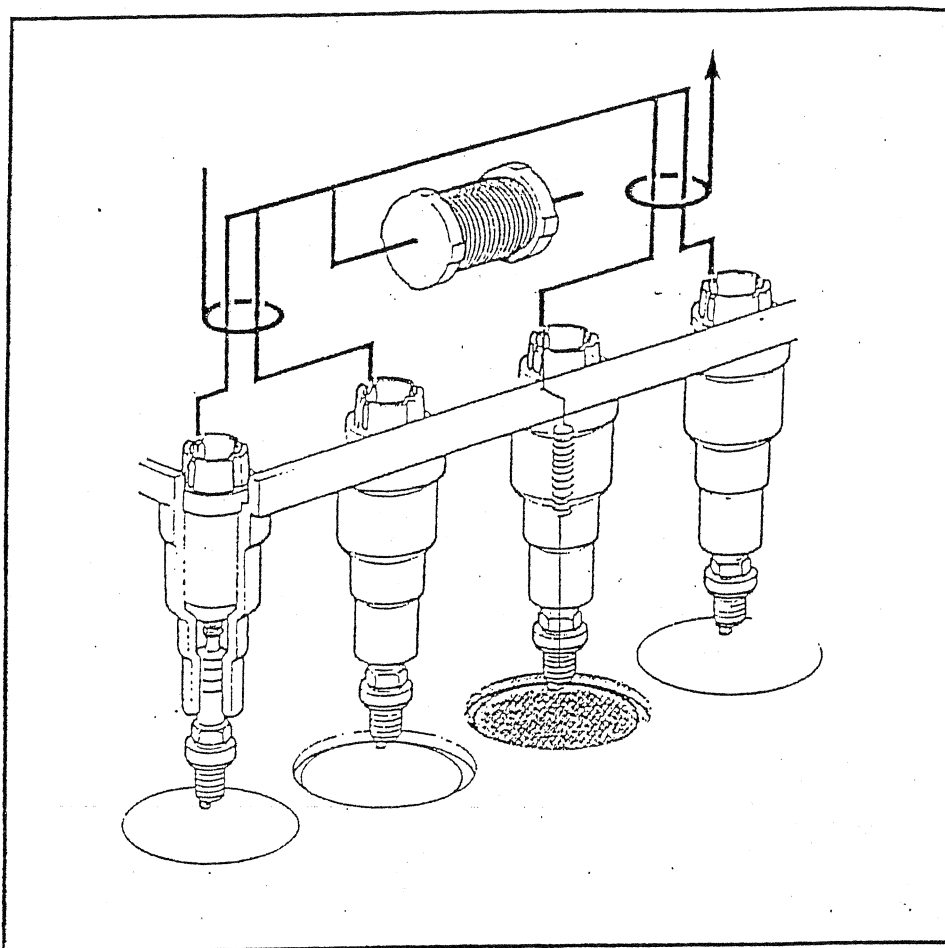
A weak current will flow through the conductor to the spark plug in cylinder 1, with the assistance of the ions in the combustion chamber and across the spark plug gap.

Two sensing circuits are provided to enable the system to determine which of the two cylinders has fired (i.e. through which conductor current has flowed). These circuits indicate the current flow, one of them monitoring cylinders 1 and 2, and the other cylinders 3 and 4.

Since the control unit knows that pistons of cylinders 1 and 4 are at the top dead centre, it is easy to determine that cylinder 1 has fired, since sensing circuit 1 and 2 indicates current flow.

Notes

22: COMBUSTION SIGNAL - NUMBER 3 CYLINDER



Cylinder 3 is the next one to fire. The sensing circuit for cylinders 3 and 4 will record that current has flowed through one of the conductors. Since the control unit knows that pistons 2 and 3 are at the top dead centre, it cannot be cylinder 2 that has fired, and it must therefore be cylinder 3.

When the mixture has been satisfactorily fired 25 times, the spark will be fired only in the cylinder containing fuel/air mixture.

Notes

23: AN EXPLANATORY STORY

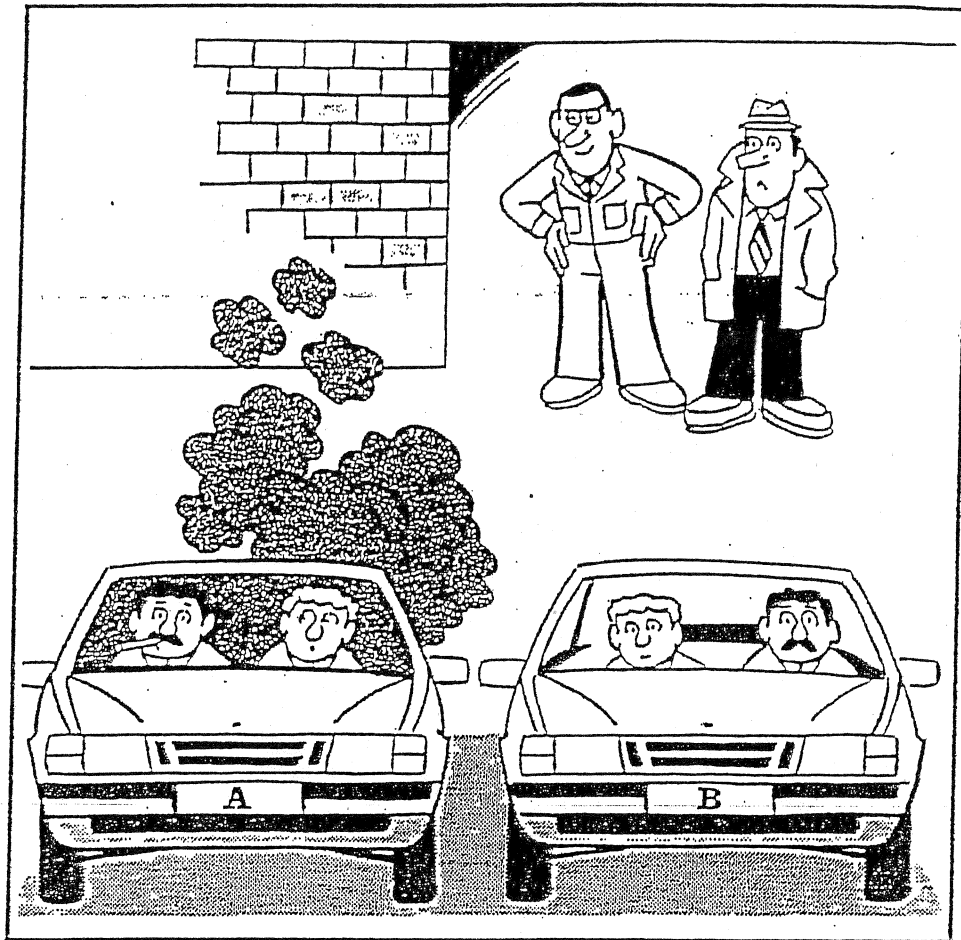


A workshop has four mechanics. All of them smoke, but smoking is not allowed in customer cars.

After a test drive of a customer's car, one of the mechanics smoked in it. The car has been tested by mechanics 1 and 4 and one of them must be guilty - but which one?

Notes

24: THE SOLUTION

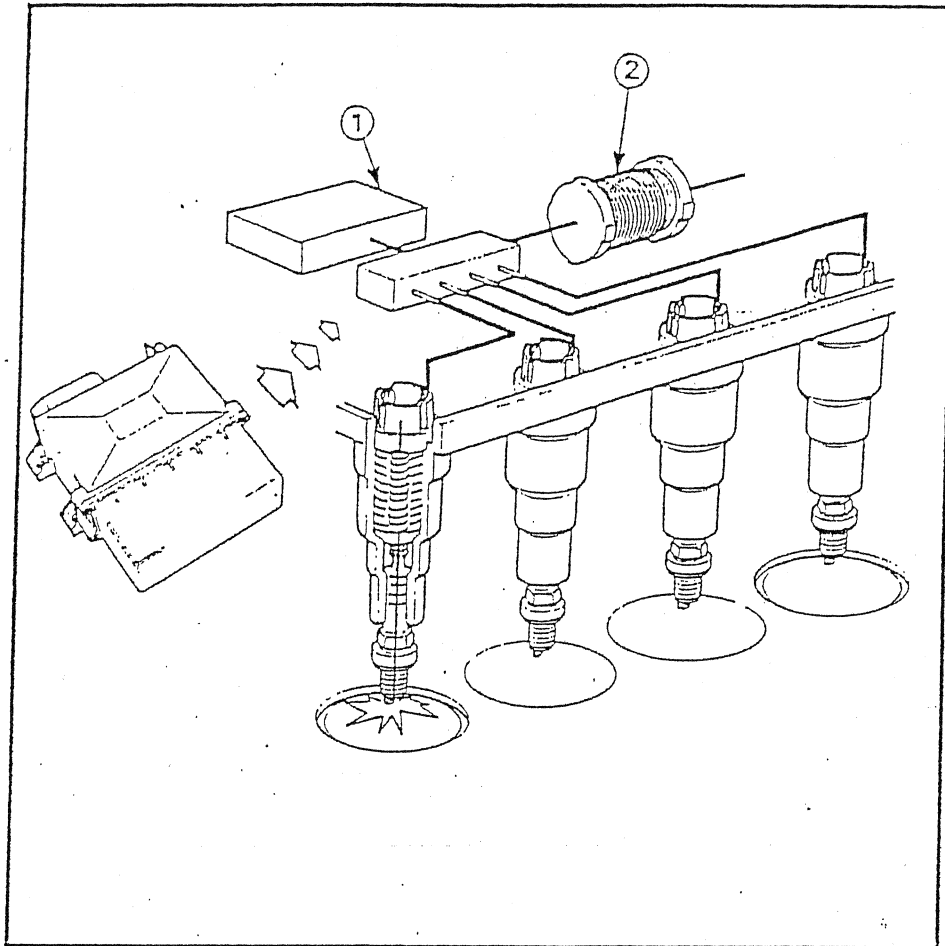


To solve the problem, he asked mechanics 1 and 2 to test drive car A, and mechanics 3 and 4 to test drive car B. He then found out that car A smelled of cigarette smoke.

Which of the mechanics smokes in customers' cars?

Notes

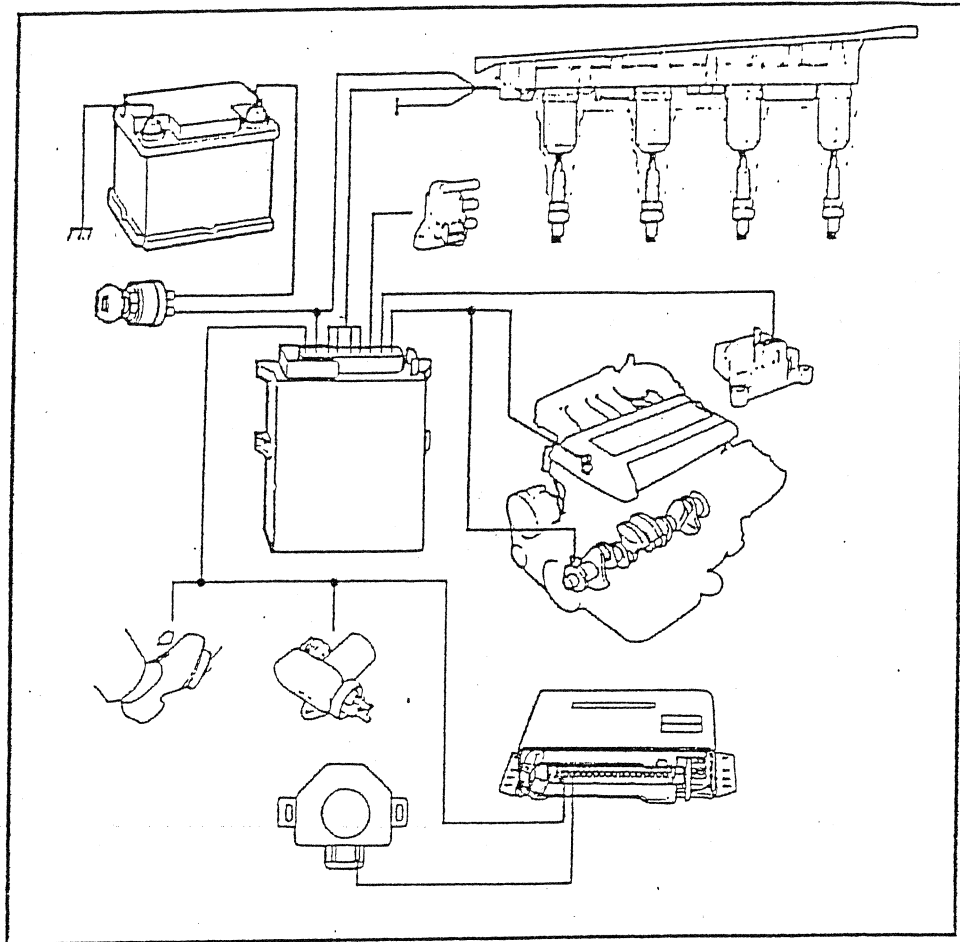
25: FIRING THE SPARK



A capacitor (1) is used for achieving the accuracy and speed necessary for starting controlled combustion at the correct instant. The capacitor is supplied with 400 Volts from the small transformer (2) next to the capacitor in the ignition cartridge. When the control unit has calculated the instant at which the spark must be fired in the combustion chamber, it will discharge the 400 Volts stored in the capacitor through the low tension winding. A high voltage, which may amount to 40 000 Volts will then be induced in the high tension winding. The spark will be fired at the correct instant and with very high reliability.

Notes

26: CONTROL UNIT

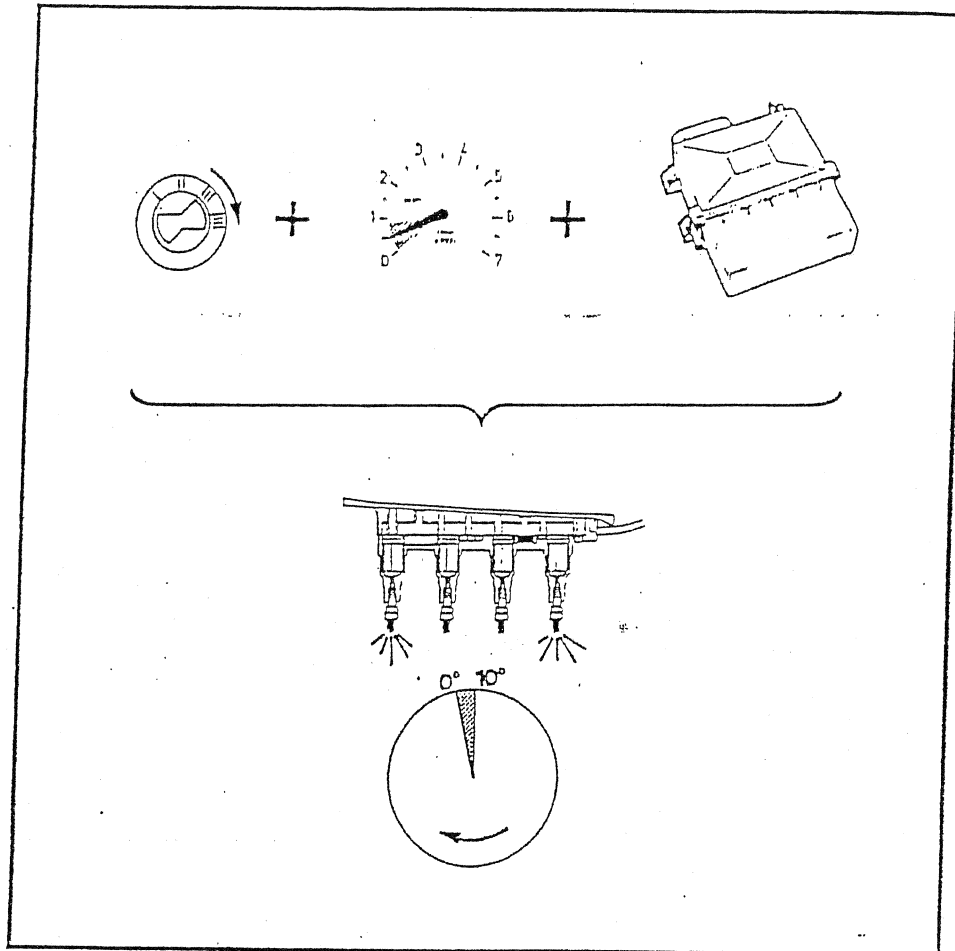


The control unit is the brain of the DI system. It is loaded with a computer program which controls the spark-firing instant and boost control. We have already described how the control unit analyses the crankshaft position, synchronises the DI system to the working strokes of the engine, diagnoses itself in the event of a fault, and changes the ignition timing and limits boost pressure to base pressure in the event of major faults.

In addition, the control unit includes a number of refinements which we shall now look at in more detail. Let us see what happens between the engine being started from cold and having warmed up to normal working temperature.

Notes

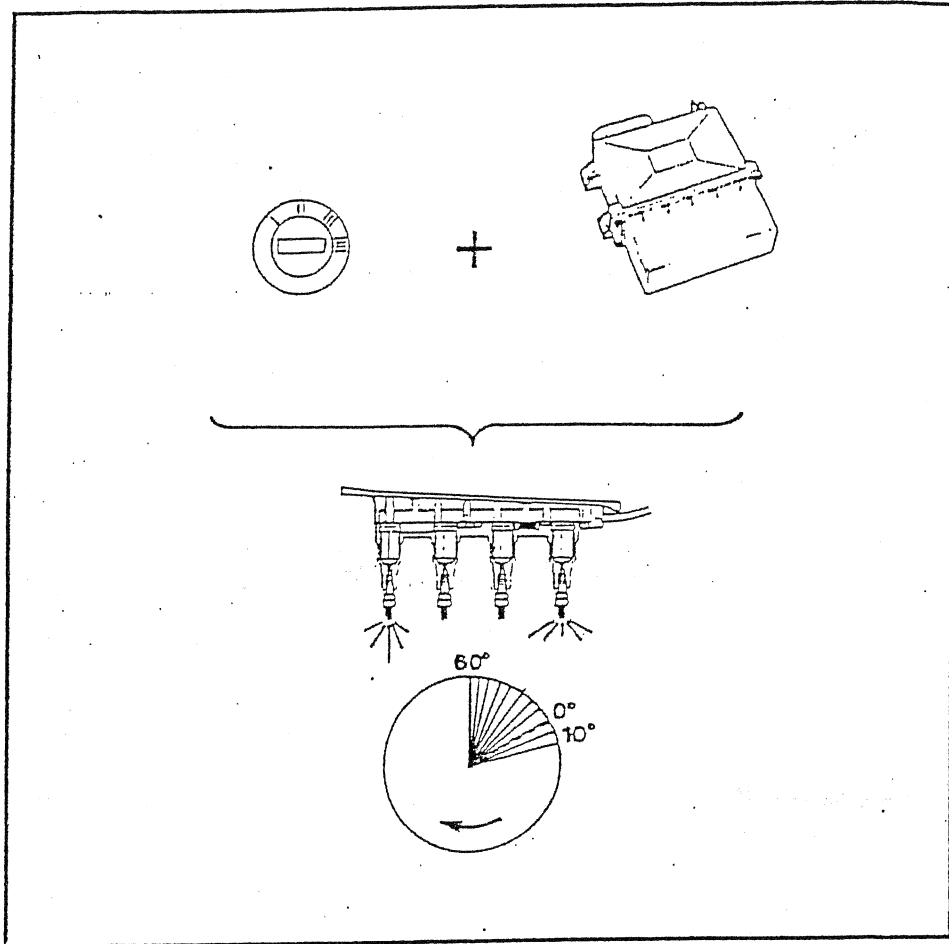
27: STARTING FROM COLD



When the driver has turned the ignition key, the starter motor will start the engine. The engine speed is below 850 r/min, which is recorded by the control unit. The control unit will then fire double sparks at a fixed ignition point of 10° BTDC

Notes

28: STARTING DIFFICULTIES

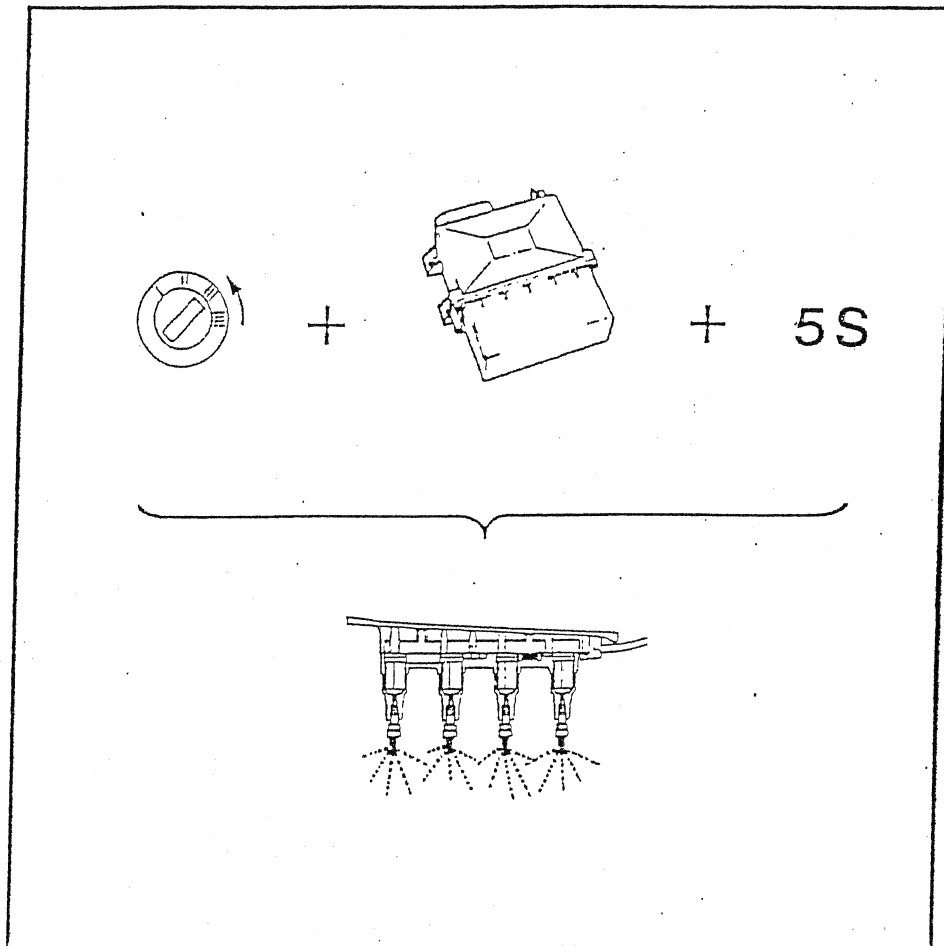


Very cold weather makes the engine difficult to start. The load on the battery is high and the engine speed is below 150 r/min. The control unit detects this and starts a 'multi-spark' sequence which lasts for 70 degrees of crankshaft rotation from the firing position. The multi-spark feature facilitates starting, but will be switched out when the engine speed has risen above 850 r/min.

If the engine speed should drop for any reason below 420 r/min after starting, the control unit will switch the multi-spark function on again.

Notes

29: THE ENGINE STILL FAILS TO START

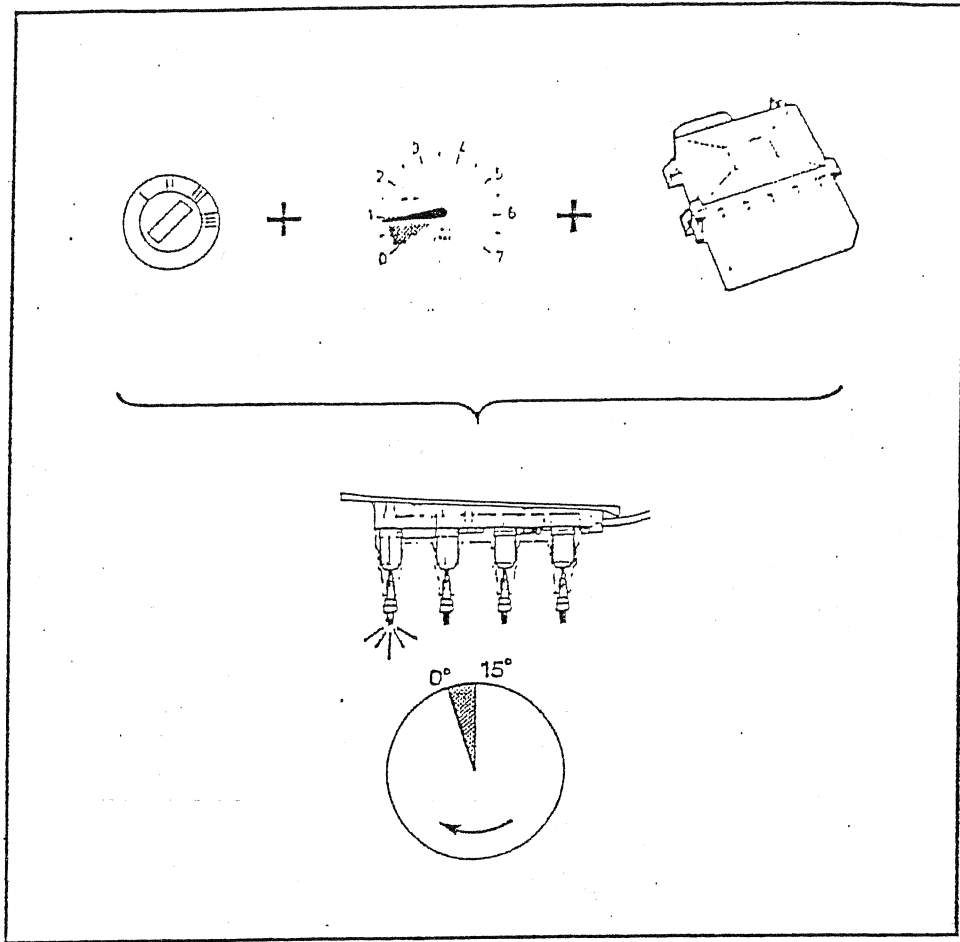


If the engine should still fail to start, the DI system will further take action: When the driver has released the ignition key and it springs back to the normal driving position, the DI system will fire a massive series of about 1000 sparks on all cylinders simultaneously. A new starting attempt can then be made immediately.

The multi-spark feature is a unique Saab idea which can only be used on a capacitive ignition system with separate ignition coils.

Notes

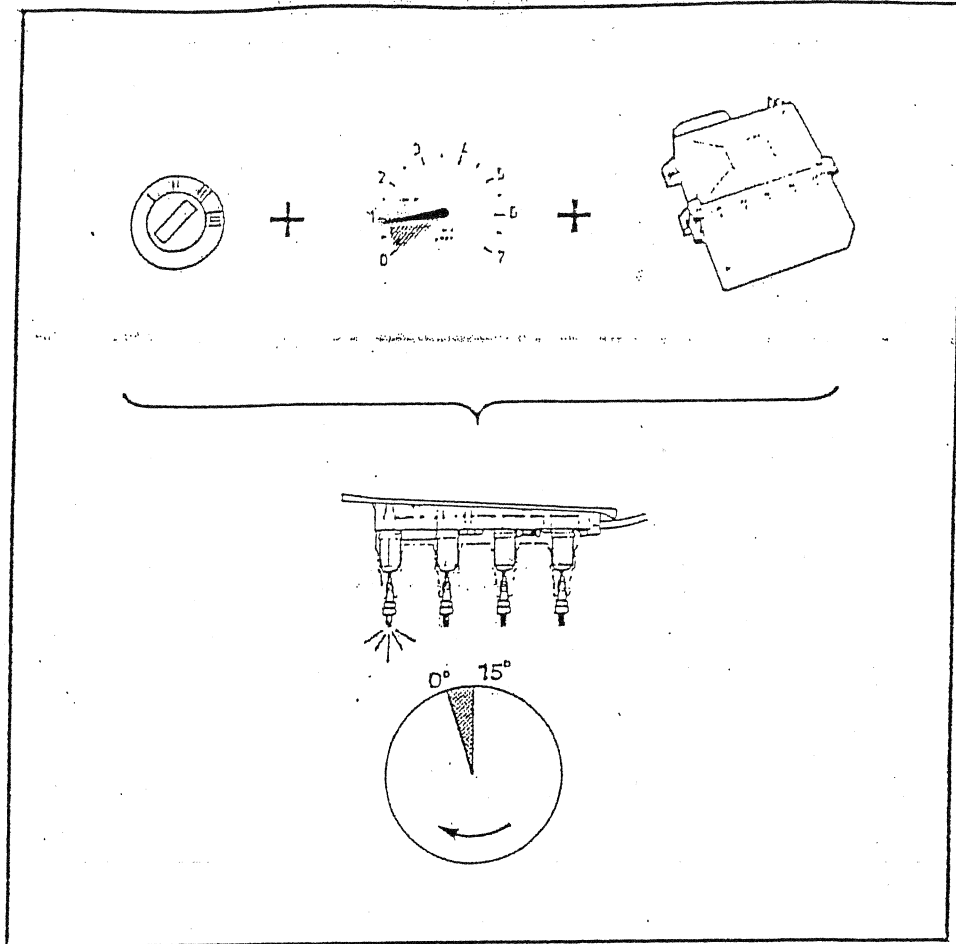
30: THE ENGINE STARTS



When the engine has started, it has one fixed ignition point at 15° BTDC between 850 and 1000 r/min.

Notes

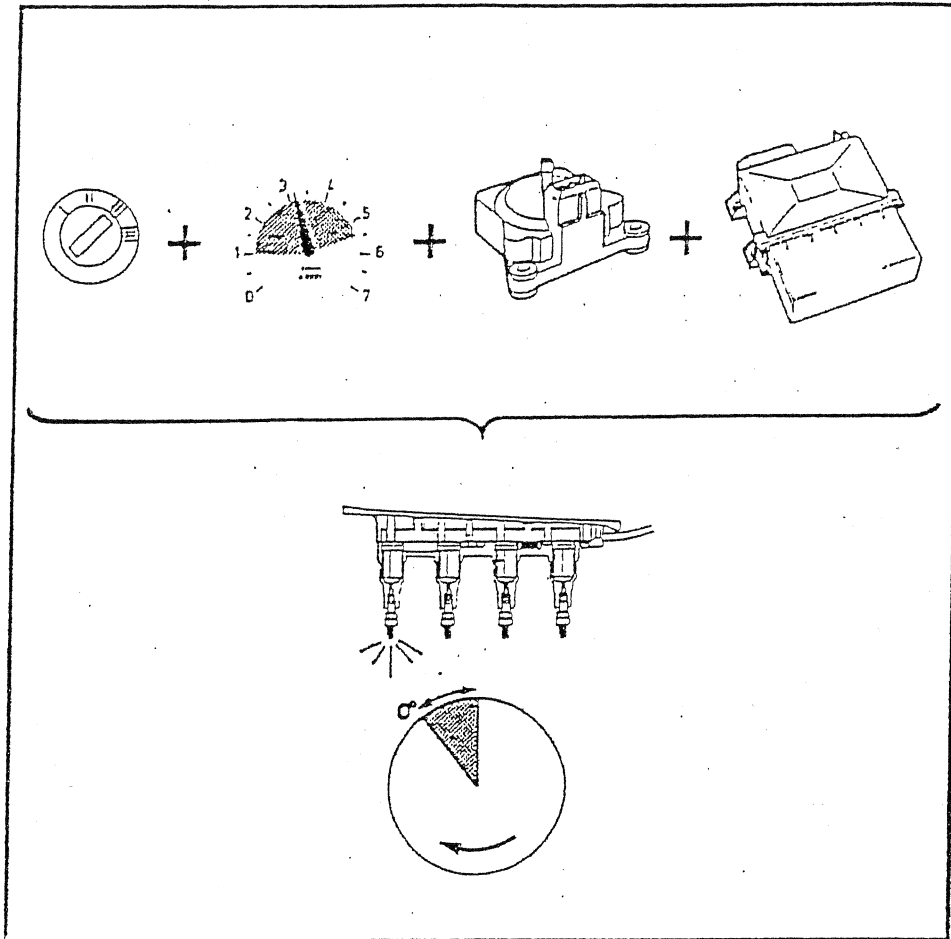
30: THE ENGINE STARTS



When the engine has started, it has one fixed ignition point at 15° BTDC between 850 and 1000 r/min.

Notes

31: NORMAL RUNNING



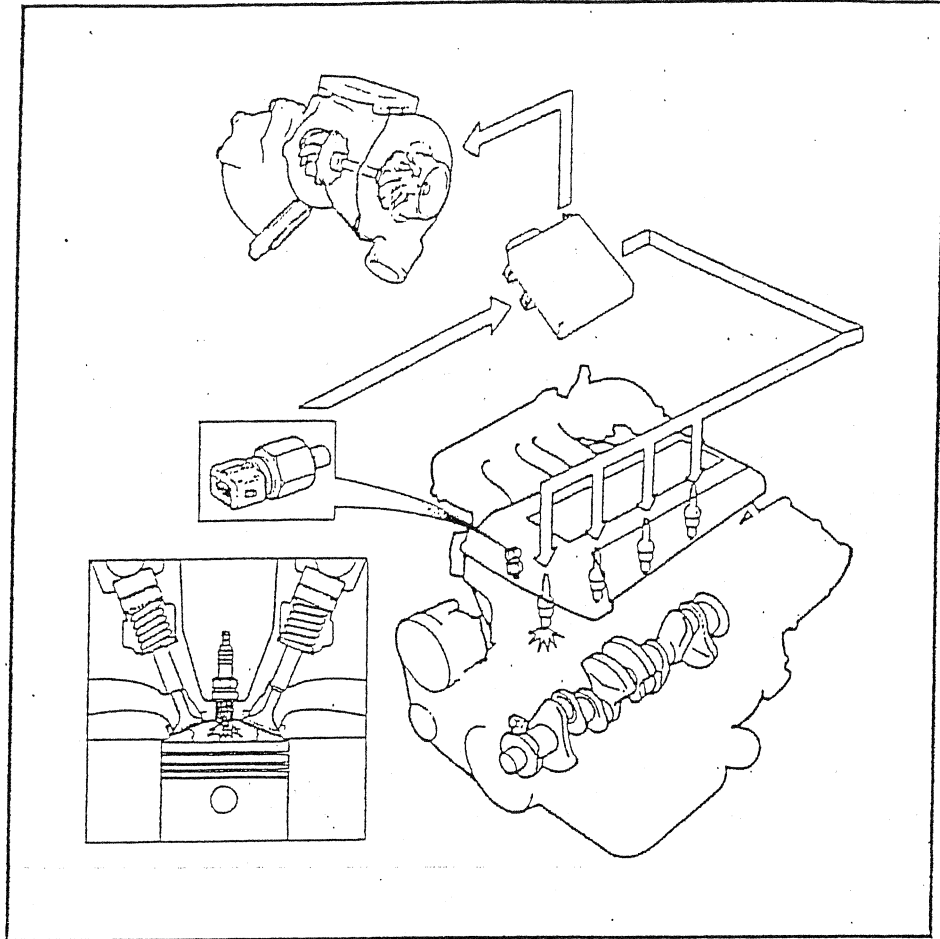
When the car is travelling, the driving conditions, engine load and engine speed will vary, and the control unit will have to vary the ignition point continuously. The ignition point is controlled by the program loaded into the control unit. This program is based on tests from which the best conceivable ignition point has been determined for different conditions.

The optimised ignition point, and the efficiency and reliability of the system, make the Saab DI system unique.

For particulars of fault tracing and work on the system, refer to the information contained in the Service Manual and the Service Information bulletins.

Notes

32: DETONATION



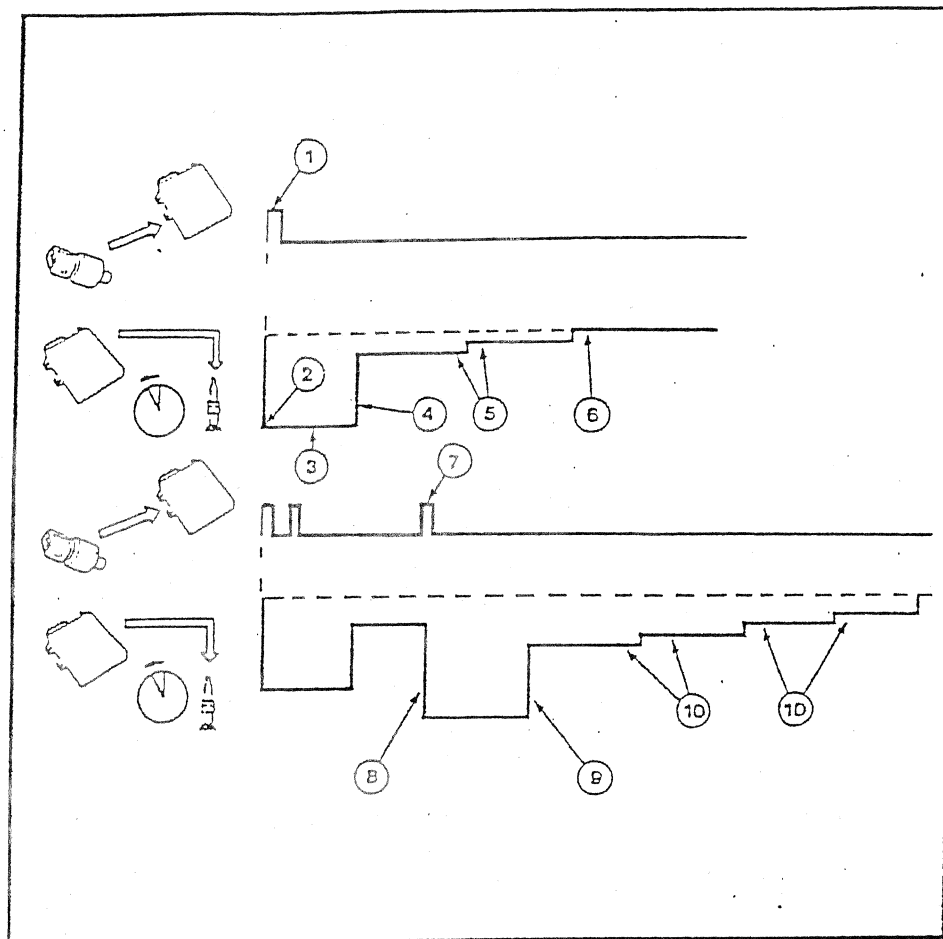
Knocking or detonation is the condition when the intake fuel air charge is ignited at points other than the spark plug during the combustion phase of the engine cycle. The resulting uncontrolled burning with several flame fronts, causes loss of power and damage to the engine.

On conventional engine systems, such as detonation can be controlled either by reducing the boost pressure or by retarding the ignition until the knocking stops.

On the DI-APC system, both boost pressure reduction and ignition retardation are used together to prevent knocking, thereby optimising engine performance.

Notes

33: IGNITION TIMING CONTROL AFTER DETONATION

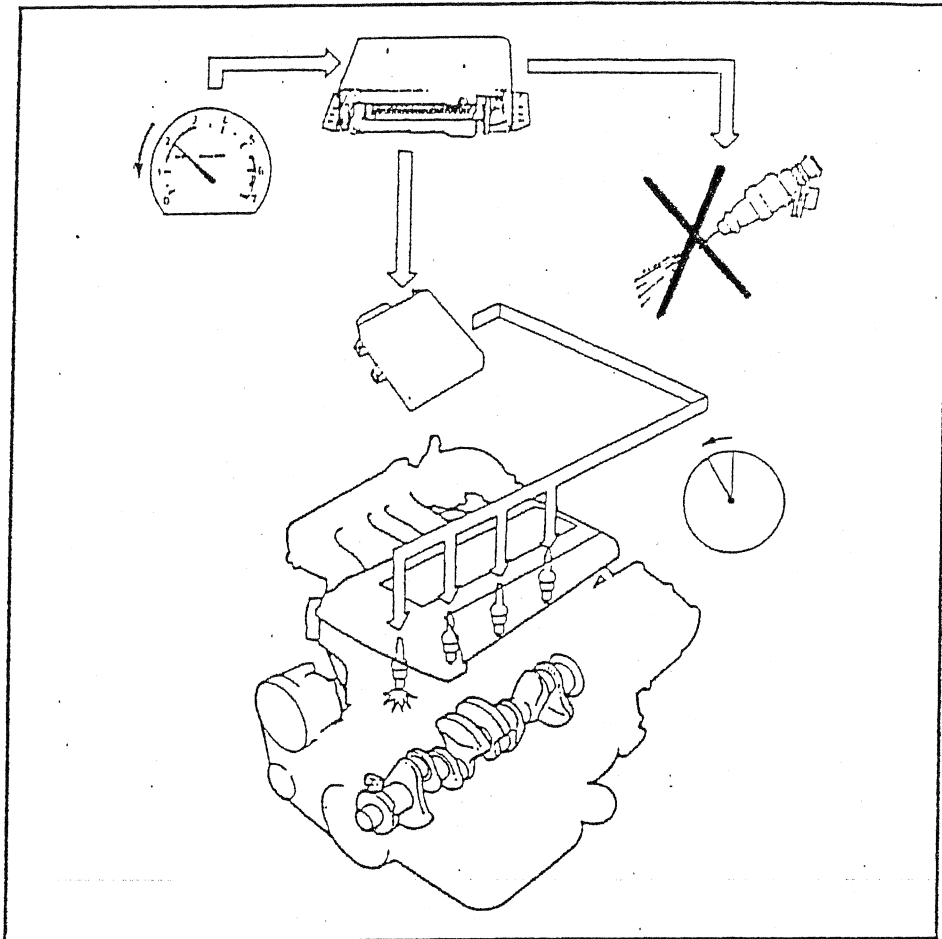


Immediately it recognises the presence of detonation (1), the control unit retards the ignition (2) and holds it at this point (3). If detonation does not recur during that period, it advances the ignition again (4) and holds it at that point. If detonation does not recur during that interval, the control unit advances the ignition timing by very small steps (5) until the original ignition timing is restored (6).

If, however, detonation recurs (7) during any of the holding phases, the control unit retards the ignition by a further steps (8) up to a maximum limit until the detonation is eliminated, when it advances the ignition timing again (9) and holds it at that point. If detonation does not recur during that interval, the control unit advances the ignition timing by small amounts (10) until the original setting is restored.

Notes

34: IGNITION RETARD DURING FUEL SHUT-OFF

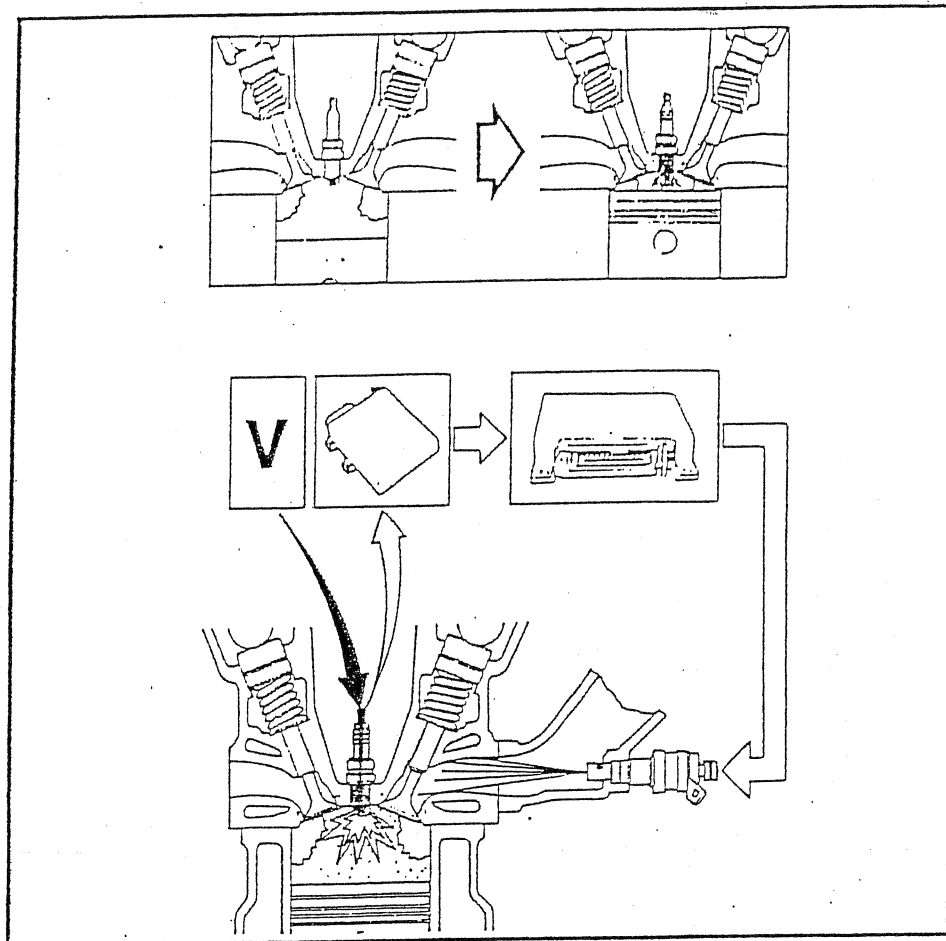


When the throttle is released with the engine speed above 2000 rpm and the car decelerates, the LH 2.4 fuel injection system halts fuel injection to reduce the Hydrocarbon emissions. At the same time the LH 2.4 fuel injection system control unit breaks a signal (the tq signal) it normally supplies to the DI-APC control unit. The absence of this signal causes the DI-APC electronic control unit to retard the ignition. This provides a smoother engine operation when the accelerator pedal is pressed again.

This function operates only when the LH 2.4 fuel injection system is fitted. It does not operate when the LH 2.2 fuel injection system is fitted

Notes

35: ENRICHMENT ON PRE-IGNITION

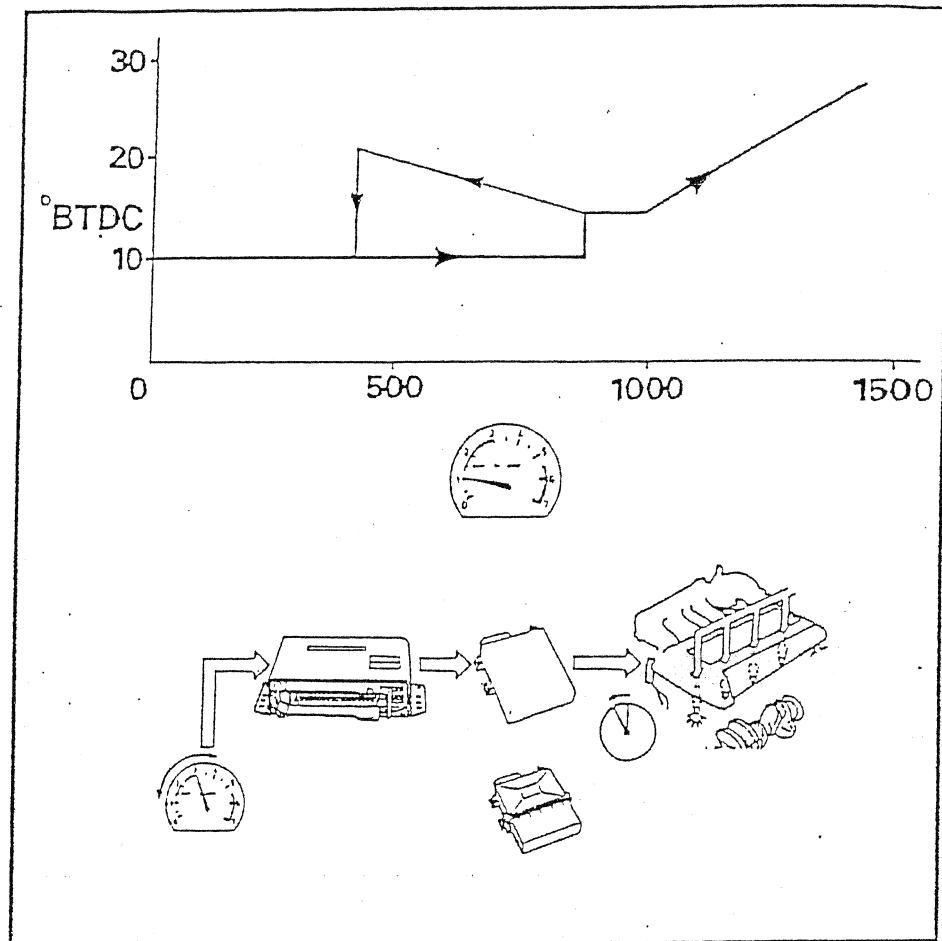


Pre-ignition is the tendency for the fuel and air mixture in the combustion chambers to ignite itself. Pre-ignition affects the engine performance and can damage the engine. Under normal operating conditions, the charge of air and fuel in the cylinder is compressed and then ignited by the spark plug so that it burns in a controlled manner. Optimum efficiency of the engine is achieved by compressing the charge as much as possible before ignition. However, as the charge is compressed its temperature rises and it can reach the point of self ignition. If this occurs, the whole charge in the combustion chamber ignites at the same time like an explosion.

Turbocharging increases the likelihood of pre-ignition occurring since the pressures in the combustion chambers are increased. The DI-APC system's electronic control unit is programmed to recognise the occurrence of pre-ignition from the combustion signals it receives from the ignition cassette. If pre-ignition occurs, the DI-APC electronic control unit issues a signal to the LH fuel injection electronic control unit causing it to inject additional fuel for a specified time. The injection of this fuel cools the combustion chambers and stops the pre-ignition.

Notes

36: IGNITION TIMING SUMMARY



Cold start - engine speed below 150 r/min
Multispark

Cold start - engine speed below 850 r/min
10° BTDC - Both cylinders

850 - 1000 r/min
15° BTDC

1000 r/min +
controlled by control unit

850 - 420 r/min (engine speed falling)
ignition timing advances

420 r/min -
10° BTDC - Both cylinders

Ignition timing is retarded during deceleration
(LH 2.4 only).

Ignition timing is retarded if detonation occurs
(LH 2.4 & LH 2.2).

Check timing at engine speed between 850 -
1000 r/min only.

Do not check AIC by old method of earthing out
AIC. Engine timing advances and speed
increases as you try to reduce engine speed.

Instead check by dwell method.

New cars below 9,300 miles (15000km) - 32°

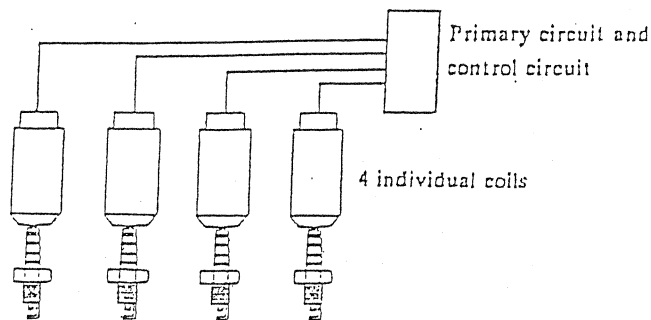
Cars above 9,300 miles (15000km) - 30°

Notes

DIRECT IGNITION (SAAB)

Saab are now using a direct ignition system on some of their 9000 series vehicles.

The direct ignition system is virtually a complete departure from the ignition systems we are generally familiar with. Although an ignition coil is used to produce the high voltage, it is only one part of the chain that allows a high voltage to be produced. When initially examining the system, the most obvious differences from conventional systems are the facts that there is one coil for each spark plug and that there are no plug leads.



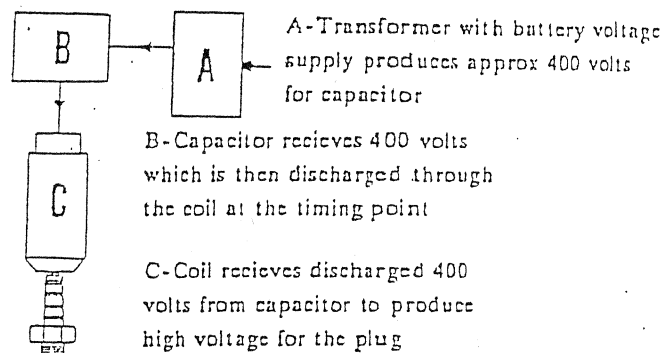
SCHEMATIC LAYOUT

As with the Ford system, where one coil is used for two spark plugs, the direct ignition system eliminates the need for a rotor arm/distributor cap assembly. The Saab system could therefore be briefly described as a system which is computer controlled (as are most new systems) and is able to provide the correct ignition timing because of information fed to the ECU by sensors (engine speed and load). The ECU is then able to establish which cylinder is due to fire and selects the appropriate ignition coil.

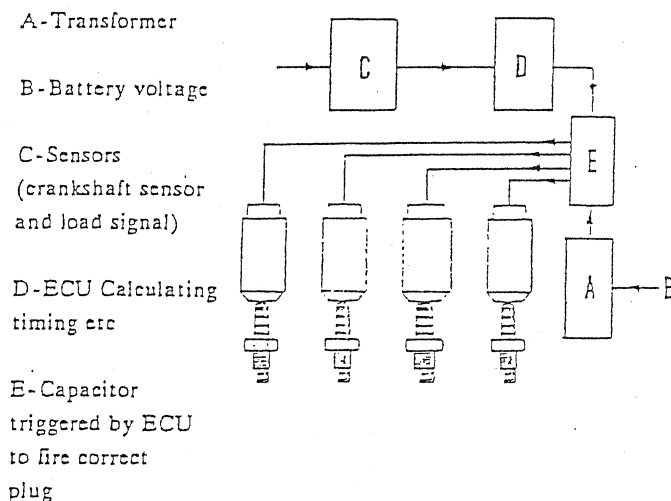
The above brief description is true but it is however not complete. The Saab system incorporates some additional design departures when compared to conventional ignition systems, the differences are relevant not only to its operation but also for testing. Apart from having one coil per cylinder, the one other major difference is that in order to produce the high voltage from the ignition coil, instead of collapsing an existing magnetic field, the Saab system relies on the rapid production of a magnetic field. The principal is known as capacitive discharge and has been used previously on a number of systems but only for limited applications such as on racing or very high performance engines.

The system makes use of a transformer which steps up the normal vehicle supply of approximately 12 volts to around 400 volts. The 400 volts is then stored by a capacitor and when the spark is required, the capacitor rapidly discharges the 400 volts through the primary winding of the ignition coil. The rapid discharge through the primary winding, induces the high voltage in the secondary winding to provide the energy for the spark. The basic advantage of using this process is that the build up of energy in the secondary winding is apparently around 20 times quicker than the build up in a normal system. This means that an intense high voltage spark is available in a very short period.

With this method of producing a spark, Saab have been able to design into the system the ability to produce a large number of sparks in a very short time period. This facility is used to overcome the possible problem of fouled spark plugs on engines that are difficult to start in cold weather. The rapid series of high voltage sparks at the plug can be implemented under certain conditions of poor starting to ensure that the plugs remain clean and capable of igniting the mixture.



PRINCIPAL OF OPERATION
(single cylinder)



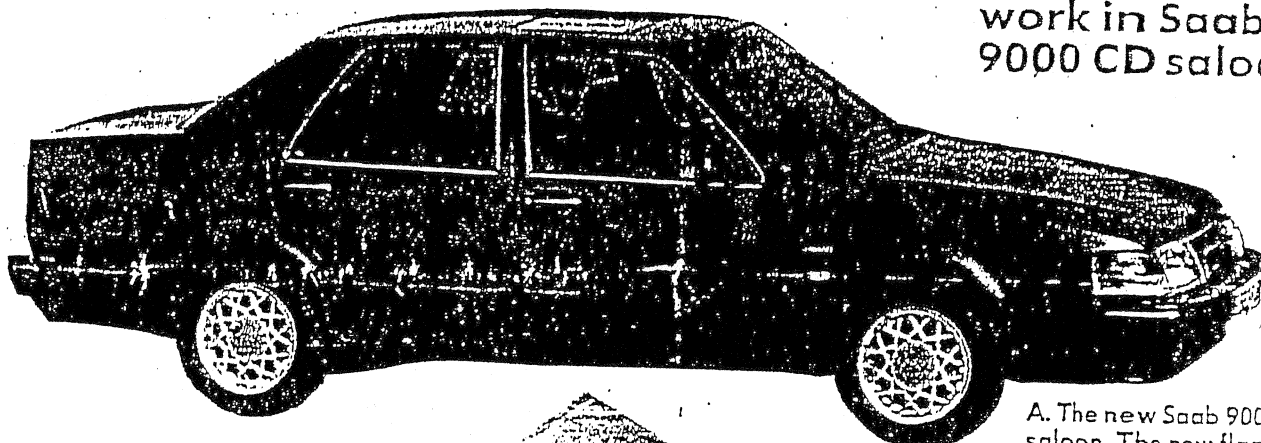
PRINCIPAL OF OPERATION
(all cylinders)

A Hall effect principal crankshaft sensor is located on the front engine pulley to provide the ECU with a reference to crankshaft position (refer to page 52 for an explanation of the Hall effect principal). The sensor also provides the ECU with an indication as to which pair of cylinders is approaching TDC. When the engine is first cranked over and started, the ECU triggers the ignition coils in pairs ie, 1 + 4 and 2 + 3, this is based on the information from the crankshaft sensor. After a small number of firing cycles have taken place, the system then determines electronically which of the cylinders in each group is firing, and for the remainder of the engines operation, each coil is triggered individually.

At the time of writing, there is little information available on testing the system. The main problem when testing is of course that there is no access to a secondary connection between the coil and the plug. At present, there are not many vehicles fitted with this system but it is intended to cover the system in greater detail in the future.

DIRECT ROUTE

Direct ignition does away with much of the spaghetti under the bonnet. Chris Wright has seen it at work in Saab's new 9000 CD saloon.



A. The new Saab 9000 CDE saloon. The new flagship of the Swedish company's line up.

It doesn't sound different and doesn't really do anything different. It just looks different.

Open the lid on Saab's new flagship and take a squint at the shining 2-litre turbocharged 16-valver and something's missing.

There's no H.T. leads. But if you are going to give each spark plug its very own coil, there's no need for them is there?

Direct ignition has been developed in-house by the Swedish company and the new 9000 saloon is the first of its cars to use it, the rest of the range will gradually follow.

With Saab DI, each spark plug has its own small, high-output coil and a micro-computer monitors the ignition process adjusting it to suit a wide variety of operating conditions.

It is a capacitive or condensor system in which the voltage is stepped up in two stages. First, the 12-volt current from the battery is increased to about 400 volts. Then, after a short period of storage in a condensor, the current is boosted to 40,000 volts.

This is compared to the conventional inductive system, in which a central coil increases the voltage from 12 to only 25,000 volts. This then has to be routed through the distributor and then through more cable to the plugs.

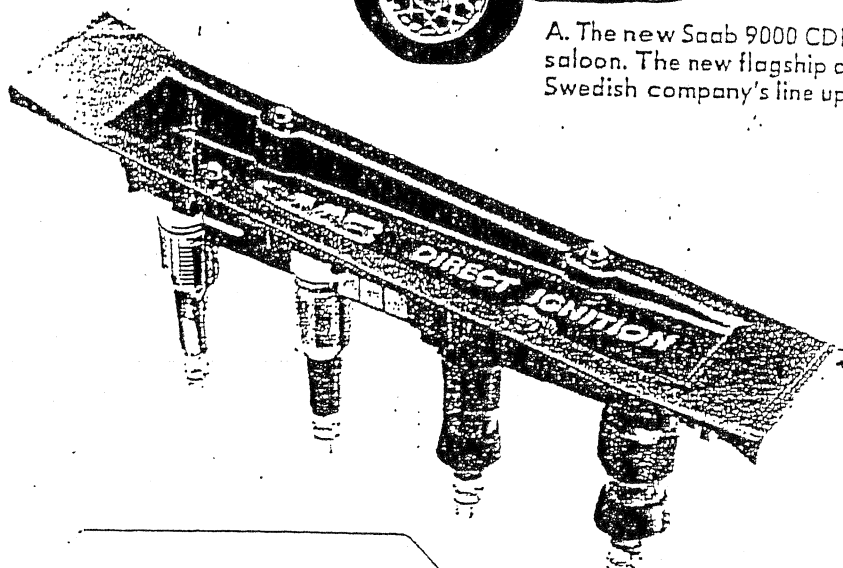
By fitting each plug with its own small coil, there is no need for a distributor and the risk of voltage leak through cracks or wet plug insulators has been eliminated.

Higher voltage can be generated and if one of these little coils should break down, the car can still be driven.

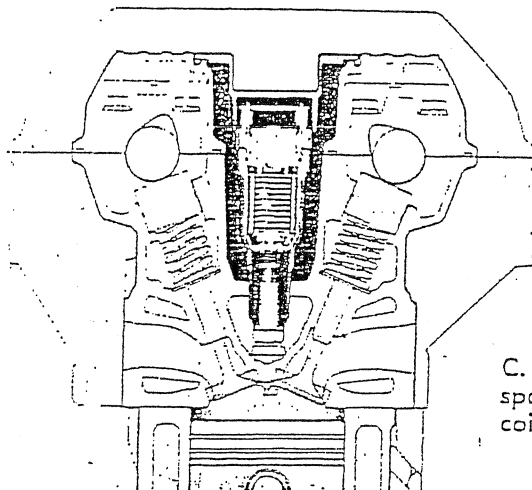
In place of a mechanical distributor, Saab DI uses a sensor to measure the rotation of the crankshaft and send signals to the microcomputer which processes the information.

Taking engine load and speed into account, it sends ignition impulses at precisely the right amount.

The microprocessor ensures that each plug fires only when necessary and enables the plug gap to be increased to



B. Saab's Direct Ignition cartridge. These bolt into the top of the cylinder head. Very easy to get at.



C. In situ. This diagram shows the spark plugs in place with the little coil sitting on top.

between 0.9mm and 1.5mm, compared to 0.6mm and 0.8mm in an inductive system. The larger gap gives longer plug life — about twice as long, Saab claims.

The system also has a "multi-spark" function so if plugs are wet, dirty or sooty, a number of 40,000 volt sparks — 50 in a fraction of a second — are fed to the next plug up the firing order.

As soon as the engine has fired up and reached 600rpm, the multi-spark operation switches off and each cylinder then gets just the one spark per engine cycle.

The system has been intensively tested for two years and Saab says that its tests have produced more miles to the gallon and cleaner exhausts.

Those who want to get an early look at the system will have to fork out anything from £22,000 to £27,000 for the new top-of-the-range Swede.

As well as the luxury equipment, you can also expect an exciting ride from the 135mph saloon.

With DI, it should also start better in damp or cold weather — ideally suited to British conditions I would have thought.