ELECTRONIC IGNITION

The increased requirements for ignition systems could not be met by the conventionalinductive ignition system since 1960. The introduction of new exhaust emission criteriain 1965 and the demand for improved fuel economy in 1975, have forced to use electronics into ignition system to meet the statutory requirements for a vehicle. Legislative requirements and driver demand for better engine performance, added tothe manufacturer's marketing strategy to offer a more sophisticated vehicle are the impetus for electronic innovation in this field.

Drawbacks of a Conventional System.

The basic principle of a conventional inductive ignition system has not changed for several decades till it became unable to meet the needs as regards energy output andcontact breaker performance. In contrast to an ignition output of 10 – 15 kV used in earlier day, the modern high-speed engine needs an output of 15 – 30 kV to ignite theweaker mixtures required to provide better economy and emission. To meet this requirement a low-inductive coil is often used. Due to much higher current flow in thiscoil, the erosive wear of the contact breaker is unacceptable. This reason alone is sufficient to adopt an electronic system in place of the mechanical breaker. The otherdrawbacks, however, of the breaker are:

(i) Ignition varies from specified value due to the change in speed because of
   (a) wear at the contact heel, cam and spindle,
   (b) erosion of the contact faces, and
   (c) contact bounce and the inability of the heel to follow the cam at high speed.
(ii) Adverse effect on the dwell time as a result of dwell angle variation.
(iii) Frequent servicing.

Electronic Ignition System

Electronic ignition is now fitted to almost all spark ignition vehicles. This is because the conventional mechanical system has some major disadvantages.

- Mechanical problems with the contact breakers, not the least of which is thelimited lifetime.
- Current flow in the primary circuit is limited to about 4 A or damage will occurto the contacts or at least the lifetime will be seriously reduced.
- Legislation requires stringent emission limits, which means the ignition timingmust stay in tune for a long period of time.
- Weaker mixtures require more energy from the spark to ensure successfulignition, even at very high engine speed.

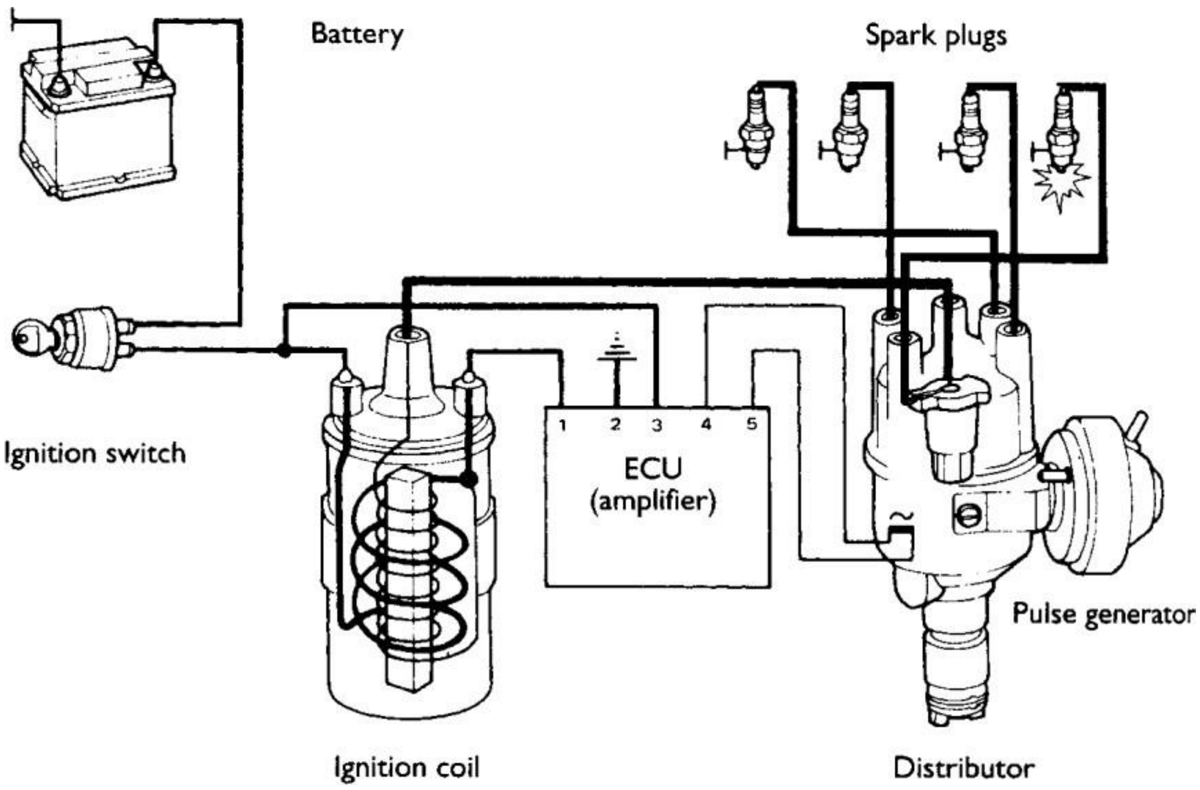

Figure 1. Electronic Ignition System

These problems can be overcome by using a power transistor to carry out the switching function and a pulse generator to provide the timing signal. Very early formsof electronic ignition used the existing contact breakers as the signal provider. This was a step in the right direction but did not overcome all the mechanical limitations, such as contact bounce and timing slip. Most (all?) systems nowadays are constant energy, ensuring high performance ignition even at high engine speed.

Digital Ignition System

Electronic Ignition System is as follow:

(a) Capacitance Discharge Ignition system
(b) Transistorized system
(c) Piezo-electric Ignition system
(d) The Texaco Ignition system

Capacitance Discharge Ignition System

It mainly consists of 6-12 V battery, ignition switch, DC to DC convertor, charging resistance, tank capacitor, Silicon Controlled Rectifier (SCR), SCR-triggering device, step up transformer, spark plugs. A 6-12-volt battery is connected to DC-to-DC converter i.e., power circuit through the ignition switch, which is designed to give or increase the voltage to 250-350 volts. This high voltage is used to charge the tank capacitor (or condenser) to this voltage through the charging resistance. The chargingresistance is also so designed that it controls the required current in the SCR.

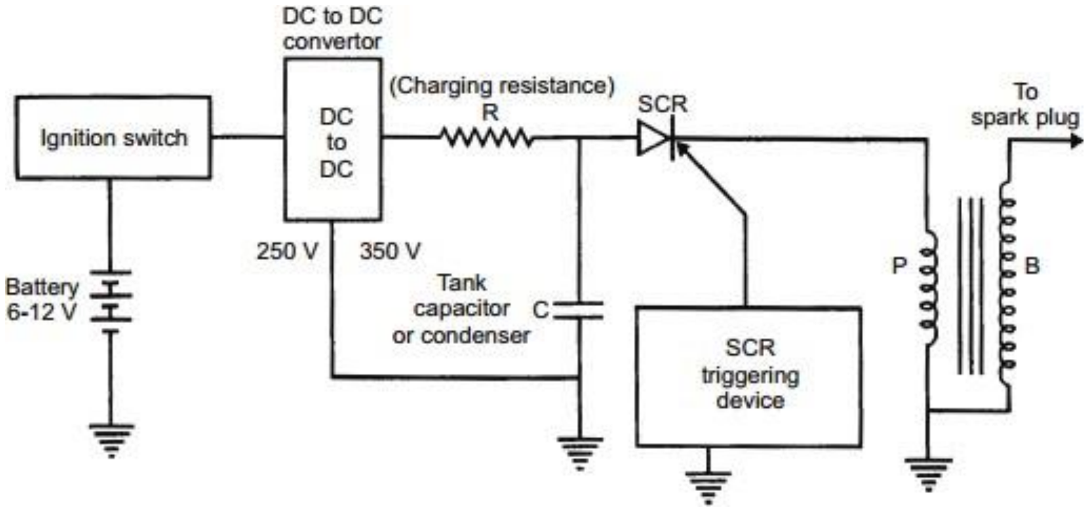

Figure 2. Capacitance Discharge Ignition System

Depending upon the engine firing order, whenever the SCR triggering device, sendsa pulse, then the current flowing through the primary winding is stopped. And the magnetic field begins to collapse. This collapsing magnetic field will induce or step-uphigh voltage current in the secondary, which while jumping the spark plug gap produces the spark, and the charge of air fuel mixture is ignited.

Transistorized Assisted Contact (TAC) Ignition System

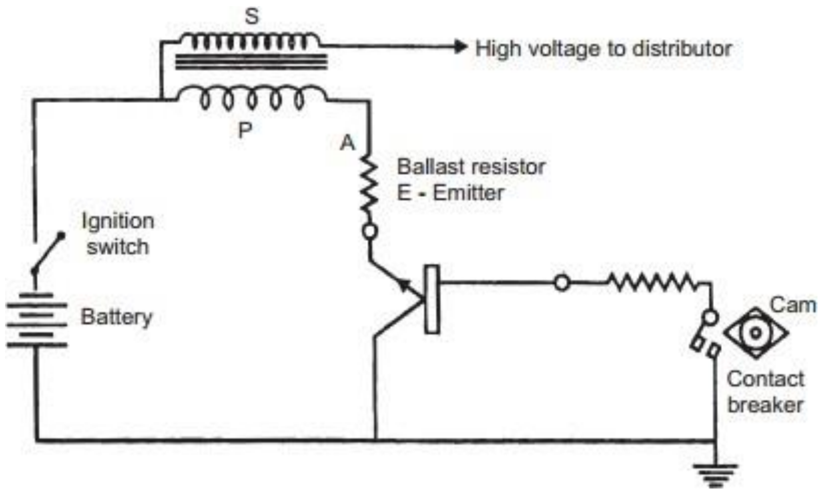

Figure 3. Transistorized Assisted Contact Ignition System

Advantages

(a) The low breaker-current ensures longer life.
(b) The smaller gap and lighter point assembly increase dwell time minimize contact bouncing and improve repeatability of secondary voltage.
(c) The low primary inductance reduces primary inductance reduces primarycurrent drop-off at high speeds.

Disadvantages

(a) As in the conventional system, mechanical breaker points are necessary fortiming the spark.
(b) The cost of the ignition system is increased.
(c) The voltage rise-time at the spark plug is about the same as before.

Piezo-electric Ignition System

The development of synthetic piezo-electric materials producing about 22 kV by mechanical loading of a small crystal resulted in some ignition systems for single cylinder engines. But due to difficulties of high mechanical loading need of the order of 500 kg timely control and ability to produce sufficient voltage, these systems havenot been able to come up.

The Texaco Ignition System

Due to the increased emphasis on exhaust emission control, there has been a suddeninterest in exhaust gas recirculation systems and lean fuel-air mixtures. To avoid the problems of burning of lean mixtures, the Texaco Ignition system has been developed.It provides a spark of controlled duration which means that the spark duration in crankangle degrees can be made constant at all engine speeds. It is a AC system. This system consists of three basic units, a power unit, a control unit and a distributor sensor. This system can give stable ignition up to A/F ratios as high as 24: 1.

Electronically–Assisted and Full Electronic Ignition System

The need for higher mileage, reduced emissions and greater reliability has led to the development of the electronic ignition systems. These systems generate a much stronger spark which is needed to ignite leaner fuel mixtures. Breaker point systems needed a resistor to reduce the operating voltage of the primary circuit in order to prolong the life of the points. The primary circuit of the electronic ignition systems operates on full battery voltage which helps to develop a stronger spark. Spark plug gaps have widened due to the ability of the increased voltage to jump the larger gap.Cleaner combustion and less deposit have led to longer spark plug life.

On some systems, the ignition coil has been moved inside the distributor cap. This system is said to have an internal coil as opposed to the conventional external one. Electronic Ignition systems are not as complicated as they may first appear. In fact, they differ only slightly from conventional point ignition systems. Like conventional ignition systems, electronic systems have two circuits: a primary circuit and asecondary circuit. The entire secondary circuit is the same as in a conventional ignitionsystem. In addition, the section of the primary circuit from the battery to the batteryterminal at the coil is the same as in a conventional ignition system.

Electronic ignition systems differ from conventional ignition systems in the distributor component area. Instead of a distributor cam, breaker plate, points, and condenser,an electronic ignition system has an armature (called by various names such as a trigger wheel, reluctor, etc.), a pickup coil (stator, sensor, etc.), and an electronic control module. Essentially, all electronic ignition systems operate in the following manner: With the ignition switch turned on, primary (battery) current flows from thebattery through the ignition switch to the coil primary windings. Primary current is turned on and off by the action of the armature as it revolves past the pickup coil or sensor. As each tooth of the armature nears the pickup coil, it creates a voltage that signals the electronic mod ule to turn off the coil primary current. A timing circuit in the module will turn the current on again after the coil field has collapsed. When the current is off, however, the magnetic field built up in the coil is allowed to collapse, which causes a high voltage in the secondary windings of the coil.

It is now operating on the secondary ignition circuit, which is the same as in a conventional ignition system. Troubleshooting electronic ignition systems ordinarily requires the use of a voltmeter and/or an ohmmeter. Sometimes the use of an ammeteris also required. Because of differences in design and construction, troubleshooting isspecific to each system.

PROGRAMMED IGNITION

General Description

The term programmed ignition is used by Rover and some other manufacturers. Ford,Bosch and some others name it electronic spark advance (ESA). Constant energy electronic ignition is commonly used in countless applications. Its limitations, however,lies on the dependence upon mechanical components for speed and load advance characteristics. In many cases these did not match ideally the requirements of the engine. Programmed ignition systems operate digitally, which is the major differencecompared to earlier systems. In this system sensed information regarding theoperating requirements of a particular engine can be programmed into memory of theelectronic control unit. The data for storage in read only memory (ROM) is obtained from rigorous testing on an engine under various operating conditions. Programmed ignition has several advantages as follows:

(i) The ignition timing can be accurately matched to the individual application under a range of various operating conditions.
(ii) Control inputs like coolant temperature and ambient air temperature can be used. Other inputs such as engine knock can be taken into account.
(iii) Starting is improved, fuel consumption as well as emissions are reduced, and idle control is better.
(iv) The number of wearing components is considerably reduced in this system. Programmed ignition or ESA can be installed as a separate system or includedas part of the fuel control system. This provides numerous possibilities in the management of the engine control.

Sensors and Inputs

The layout of the Rover programmed ignition system is shown in Figure 4 Certain input information is required by the ECU to calculate suitable timing and dwell outputs.

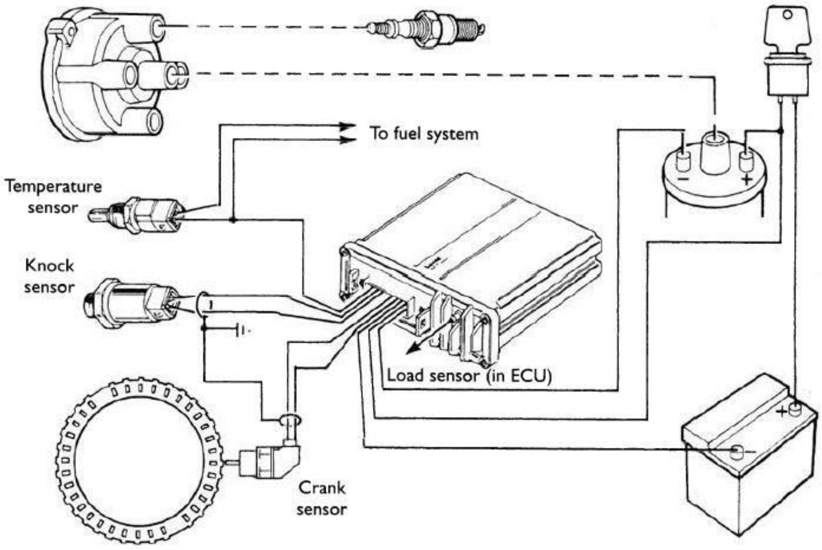

Figure 4. Programmed Ignition System

Crankshaft Sensor for Engine Speed and Position.
The crankshaft sensor is a simple reluctance sensor (Fig. 5), which is consisted of a permanent magnet, a winding and a soft iron core and is mounted close to a reluctordisc. The disc has 34 teeth spaced at 10 degrees intervals around the periphery of thedisc and has two teeth missing at 180 degrees, and at a known position before TDC.This technique, with minor changes is used by many manufacturers. When a tooth ofthe reluctor disc passes the core of the sensor the reluctance of the magnetic circuit is changed, which induces a voltage in the winding, because the frequency of the waveform is proportional to the engine speed. The missing tooth causes a missed output wave, which is used to determine engine position.

Manifold Absolute Pressure Sensor for Engine Load.
Since engine load is proportional to manifold pressure, high load conditions produce high pressure and lower load conditions such as cruise produce lower pressure. Loadsensors are therefore pressure transducers and are either mounted in the ECU or as a separate unit. They are connected to the inlet manifold with a pipe. The pipe oftenhas a restriction to damp out fluctuations and a vapour trap to prevent petrol fumes reaching the sensor.

Engine Coolant Temperature Sensor.
Coolant temperature measurement is carried out by a simple thermistor, which is alsoused, in many cases, for the operation of the temperature gauge and to provide information to the fuel control system. The basic timing settings are corrected using aseparate memory map.

Detonation (Knock) Sensor.

An engine may face serious damage due to combustion knock or detonation if subjected for long periods. The over-advanced ignition timing causes this knock. On the other hand, an engine in general runs most efficiently when the timing is advancedas far as possible. To achieve this, the basic timing map should provide the data as close to the knock limit of the engine is possible (Fig. 6). The knock sensor provides amargin for error. The sensor is often of the piezo-electric type accelerometer and fittedin the engine block between cylinders two and there on in-line four-cylinder engines.V-engines require two sensors, one on each side. The ECU receives the signals from the knock sensor in the engine's knock window for each cylinder. This is often just a few degrees each side of TDC. This prevents clatter from the valve mechanism beinginterpreted as knock. If detonation is detected, the ignition timing is retarded on the fourth ignition pulse in four-cylinder engine in steps until knock is no longer detected. A 2 degrees step is typical although the steps vary between manufacturers. The timingis then advanced slowly in steps of less than 1 degree over a number of engine revolutions, until the advance required is restored. This fine control allows the engineto be run very close to the knock limit without risk of engine damage.

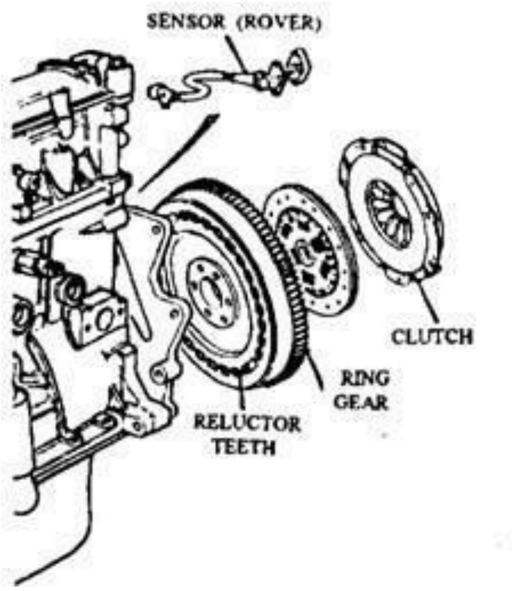

Figure 5. Reluctance engine speed and position, crankshaft sensor.

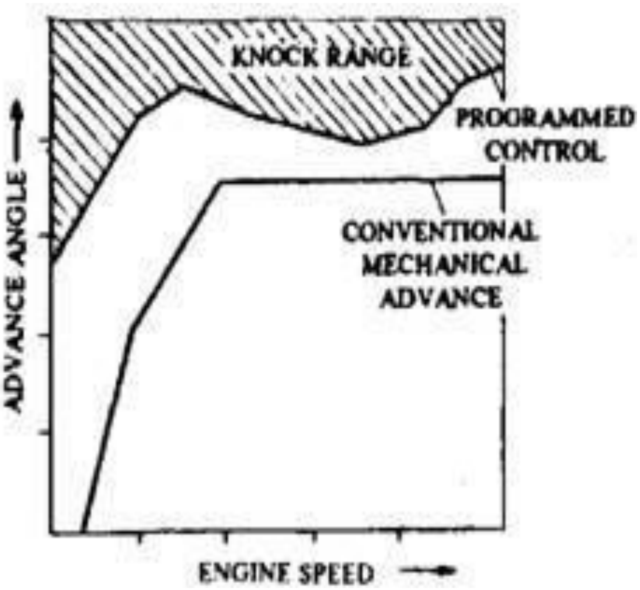

Figure 6. Knock limit of an engine.

Battery Voltage.

A lower voltage supply to the coil requires a slightly higher dwell figure, therefore correction to dwell settings becomes necessary when the battery voltage falls. This information is often stored in the form of a dwell correction map.

Electronic Control Unit

With the increase of sophistication of systems, the information held in the memory chips of the ECU has also increased. The earlier versions of programmed ignition system of Rover attained ignition timing accuracy of ± 1.8 degrees, whereas a conventional distributor is accurate to ± 8 degrees. The information, which is obtainedfrom dynamometer tests and running tests in the vehicle, is stored in ROM. The basictiming map contains the correct ignition advance for 16 engine speeds and 16 engineload conditions (Fig.7).

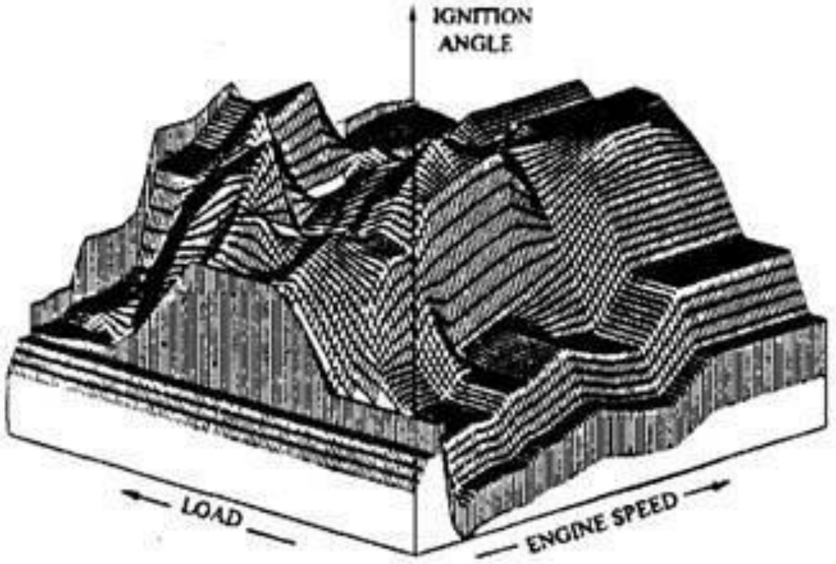

Fig. 7. Cartographic representation of a basic timing map.

A separate three-dimensional map, containing eight speed and eight temperature locations, is also used to incorporate corrections for engine coolant temperature to thebasic timing settings. This improves driveability and can be used to decrease the warm-up time of the engine. The data also need an additional load correction below 343 K. Figure 9 represents a flow chart for logical selection of the optimum ignition settings. The ECU also incorporates corrections to the dwell angle, due to changes inbattery voltage and also as a function of engine speed to provide constant energy output. A slightly longer dwell is required for a lower battery voltage and a slightly shorter dwell for higher voltage.

A block diagram of a typical programmed ignition ECU is shown in Fig. 9. Input signalsare processed and the data provided is stored in RAM whereas the program and pre-set data are held in ROM. A micro-controller is used to execute sequences demandedby the program. The sensors readings are converted to a digital representation in ananalogue-to-digital circuit. Many manufacturers including Rover use an on-board pressure sensor to indicate engine load and is consisted of an aneroid chamber and strain gauges.

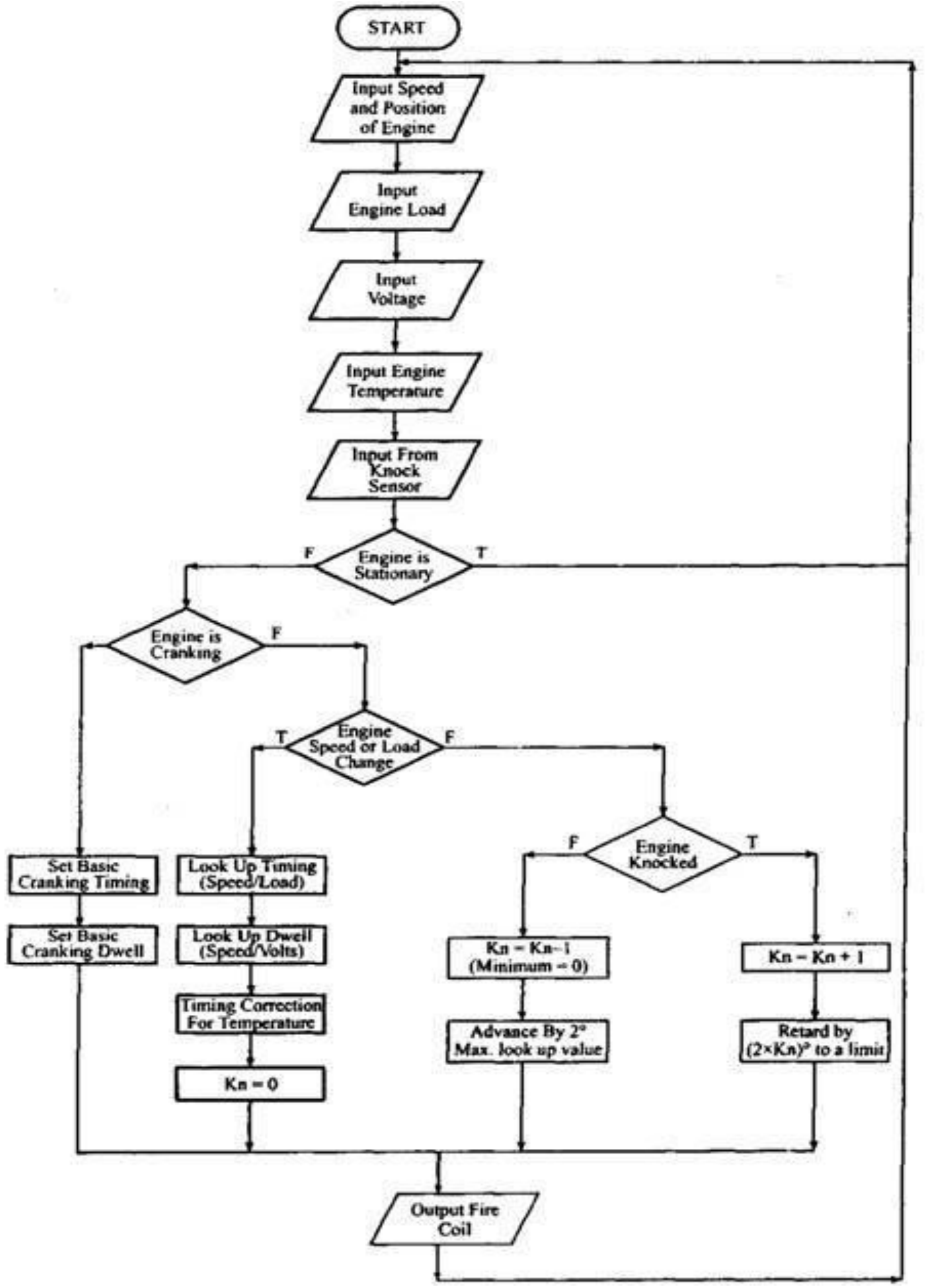

Fig. 8. Flow chart for the logical selection of optimum ignition timing.

Figure 8 shows a flow chart used to represent the program held in ROM. The programmed ignition system of Rover including the electronic control unit was quite advanced and shown high reliability compared to other contemporary systems.

Ignition Output

The output from this programmed ignition is very simple and is in common with mostelectronic ignition. The output stage consists of a heavy-duty transistor, which formspart of, or is driven by, a Darlington pair. This allows control of the high ignition primarycurrent. The switch-off point of the coil controls ignition timing whereas the switch-onpoint controls the dwell period.

High Tension Distribution

The high-tension distribution is similar to a conventional system. The rotor arm, however, is installed at the end of the camshaft. The distributor cap is positioned overthe top and is fixed on a base plate made of Crasline. This mounting point prevents any oil, which leaks from the camshaft seal, fouling the cap and rotor arm. The cap ismade of Vela, which is similar to epoxy resin but has better electrical characteristics. The mounting plate also prevents the build-up of harmful gases such as ozone and nitric oxide by venting them to the atmosphere. These gases are generated by the electrolytic action of the spark as it jumps the air gap between the rotor arm and thecap segment. The rotor arm is also made of Crasline and is reinforced with a metal insert to relieve fixing stresses.

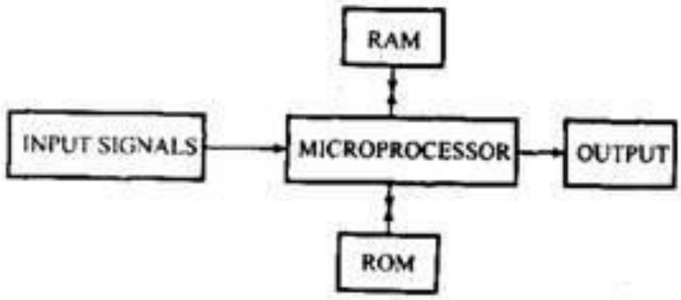

Fig. 9. Programmed ignition ECU block diagram.