Emission and Evaporative Loss Control Systems

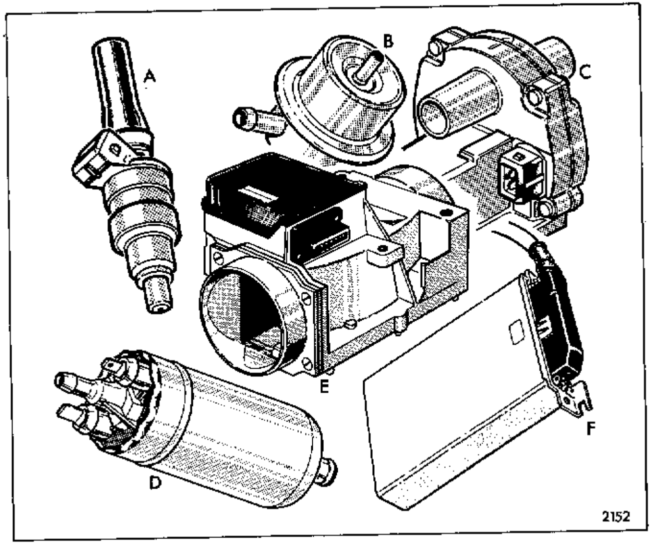

Fig. 1. **Fuel injection system components**

Key to Fig. 1

A.	Fuel injector	D.	Fuel pump
B.	Fuel pressure regulator	E.	Airflow meter
C.	Extra air valve	F.	Electronic control unit

Fuel injection system — Fig. 1

Fuel is drawn from a tank at the rear of the vehicle and pressurized to approximately 2.5 kgf/cm² (36 lbf/in²) by an electric fuel pump located beneath the car floor. The fuel pump will only operate when the ignition and/or the starter motor circuits are energized. From this pump fuel passes through fuel filter located in the engine compartment to a pressure regulator, the spring chamber of which is connected to the engine intake manifold. As a result, the difference between the intake manifold pressure and the fuel pressure is held constant, excess fuel being returned to the fuel tank via an anti-surge chamber.

A fuel rail links the pressure regulator with the fuel injectors, one injector being fitted into each inlet manifold spur. The injectors may be either 'open' or 'closed' and are solenoid-operated. The injector solenoids are energized through a relay actuated by the ignition circuit and are pulsed to 'open' by the electronic control unit (E.C.U.) completing the circuit to 'earth'. When 'open' the injectors spray fuel into the inlet manifold to be drawn into the engine cylinders at the next induction stroke of the working cycle.

Therefore there needs to be no fixed relationship between the injector timing and the engine ignition or valve timing.

The injectors are programmed to 'open' in banks of four, in unison, twice per engine operating cycle (two revolutions). On eight-cylinder engines the two banks of four injectors operate alternately. The time that the injectors are 'open' governs the amount of fuel supplied to the engine and this 'open' time is computed by the electronic control unit from the input is receives from various sensors.

Key to Fig. 2

1. Fuel feed pipe from tank
2. Fuel filter
3. Fuel rail
4. Pressure regulator
5. Fuel inlet to pressure regulator
6. Manifold depression to pressure regulator pipe
7. Excess fuel return to tank from pressure regulator
8. Injectors
9. Cold start injector fuel feed pipe
10. Cold start injector

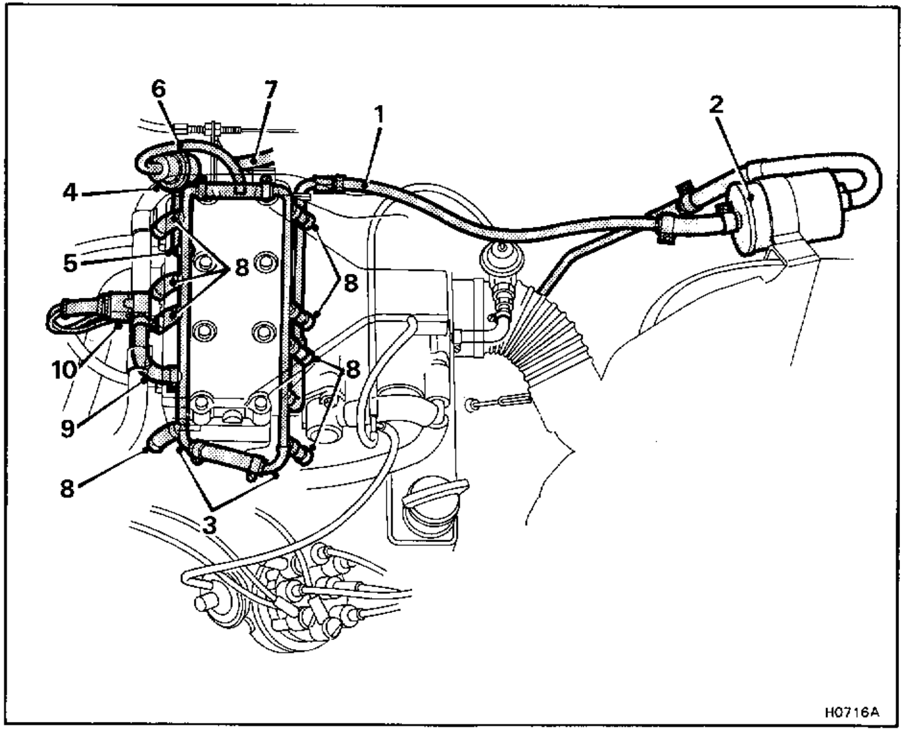

Fig. 2. Fuel injection system components

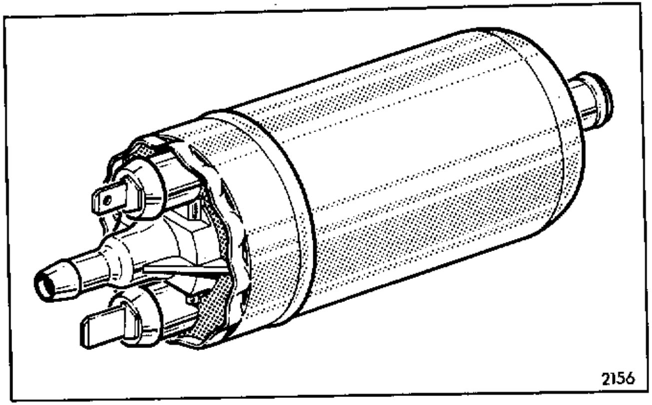

Fig. 3. Electric fuel pump

Electric fuel pump operation — Fig. 3

The fuel pump is energized, independently of the electronic control unit, from an output terminal on the combined relay. The combined relay is the component that provides an interface between the main vehicle electrical harness and those items that are specifically related to the electronic fuel injection system. An inertia switch is included in the circuit to isolate the fuel pump and prevent it from operating in the event of an impact-type accident. The circuit is also routed through the electronic control system airflow meter where a simple contact switch ensures that the fuel pump cannot operate when no air is flowing into the engine, i.e. the engine is not running. This contact switch is by-passed when the starter motor circuit is energized.

Once the engine is running, a circuit from the ignition switch passes through a relay to earth. When energized, this relay permits a circuit to be made to the airflow meter contact switch. Providing the contact switch is closed a circuit is completed through a second relay, again to earth. When energized, this second relay completes the circuit to operate the fuel pump.

Under engine starting conditions the airflow meter contact switch would normally isolate the fuel pump as no air is flowing through the engine. To overcome this, an input is taken direct from the starter motor circuit to energize the second relay and thus permit the fuel pump to operate during the engine starting operation.

Cold starting fuel injection system components — Fig. 4 and 5

To assist cold starting, a separate cold start injector sprays a fine jet of fuel against the air stream entering the plenum chamber before fuel is added to it by the main injectors. The cold start injector is energized from the engine starter motor circuit and has in series with it a Thermotime switch. This switch is dual-activated by the engine coolant temperature (heat) and a heater coil around a bi-metal strip (time), the coil being again energized from the starter motor circuit. The purpose of the Thermotime switch is to ensure that the cold start injector will not be energized when the engine is at normal operating temperature or should the starter motor be used for prolonged periods when the engine is below normal operating temperature. Thus the switch prevents extra fuel being supplied to the engine when it is not required. The switch will isolate the cold start injector after approximately 8 to 12 seconds at −20°C (−4°F), decreasing this time as the engine approaches its normal operating temperature.

Although the cold start injector and Thermotime switch operate independently of the electronic control unit, an input to the E.C.U. is taken from the starter motor circuit. This input causes the E.C.U. to slightly lengthen the time that the main injectors are 'open', thus allowing more fuel to be supplied to the engine whenever the starter motor is operated. This takes place irrespective of the information supplied to the E.C.U. by the other sensors or any operation of the cold start injector.

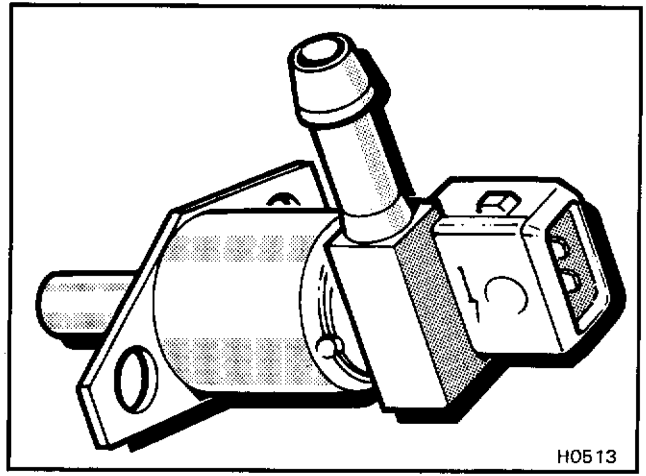

Fig. 4. Cold starting injector

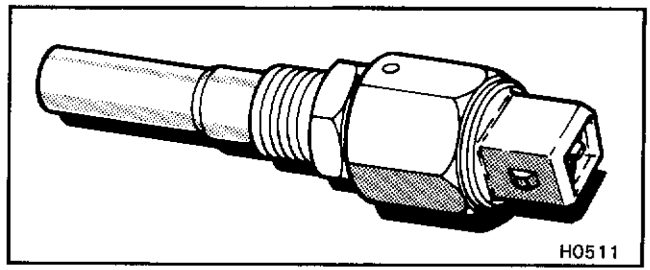

Fig. 5. Thermotime switch

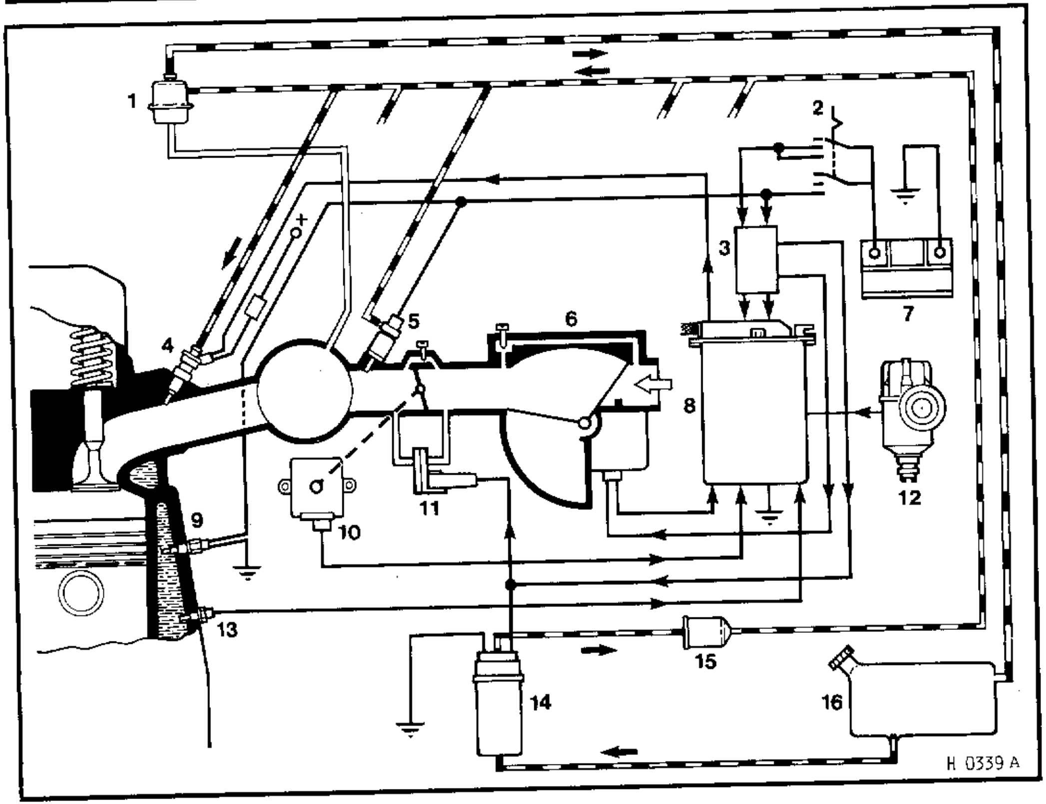

Fig. 6. Electronic fuel injection system

Key to Fig. 6

1. Pressure regulator
2. Ignition start switch
3. Relay
4. Fuel injector
5. Cold start injector
6. Airflow meter
7. Battery
8. Electrical control unit (E.C.U.)
9. Thermotime switch
10. Throttle switch
11. Extra air valve
12. Distributor
13. Coolant temperature sensor
14. Fuel pump
15. Filter
16. Fuel tank

Electronic control of the fuel injection system — Fig. 7
At the heart of the system is the electronic control unit (E.C.U.) which is located beneath a plate on the front passenger footwell. The E.C.U. receives input signals from various sensors and computes from these an output signal to the fuel injector solenoid circuits. When activated, the solenoids 'open' the injectors to spray fuel into the engine inlet manifold.

The electronic control unit is sealed; it requires no maintenance and should not be tampered with.

Engine speed
One of the first inputs required by the E.C.U. is that of engine speed, and this input is very simply obtained by taking a tapping from the ignition coil low-tension circuit output (negative terminal). Thus the ignition low-tension circuit pulses are passed to the E.C.U. to be computed into an engine speed input.

Airflow meter — Fig. 8
In addition to fuel, the most important input to the engine is air, and the ratio of air to fuel affects both the performance of the engine and the emission levels of the exhaust gases. Electronically controlled fuel injection systems can 'measure' the air used by the engine in one of two ways: by air pressure or by airflow. The airflow alternative is used on these models.

To measure the airflow into the engine an airflow meter is fitted in the engine compartment between the air cleaner and a plenum chamber above the engine. The plenum chamber acts as a collecting box for the ingoing air and helps to smooth out any rapid fluctuations in airflow that might upset the airflow meter signals.

The airflow meter itself is basically a short tube in which there is a pivoted measuring flap that is moved by air flowing past it into the engine. To reduce excessive fluttering of this flap, such as would be caused by sudden changes or pulses in the airflow, a compensating flap is fitted as part of the same casting as the measuring flap. The position of the measuring flap is controlled by the air drawn into the engine and the action of a coil return spring.

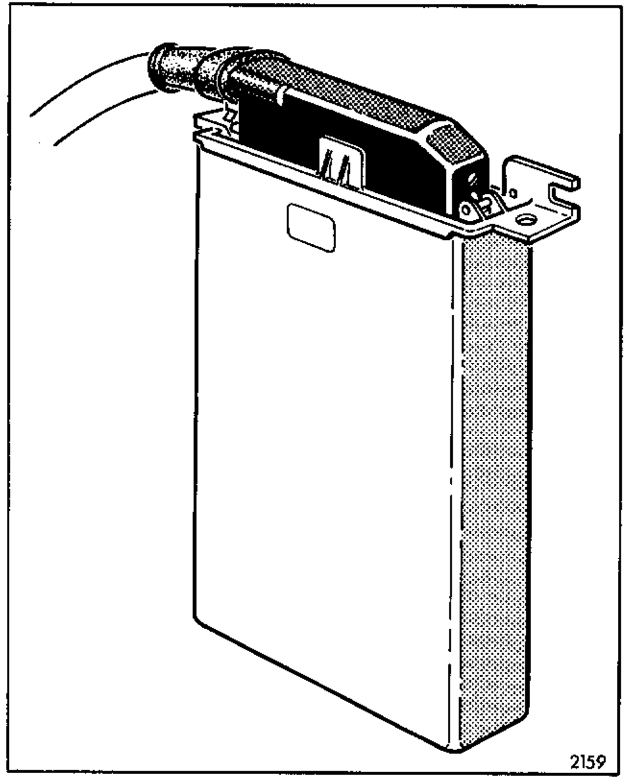

Fig. 7. Electronic control unit

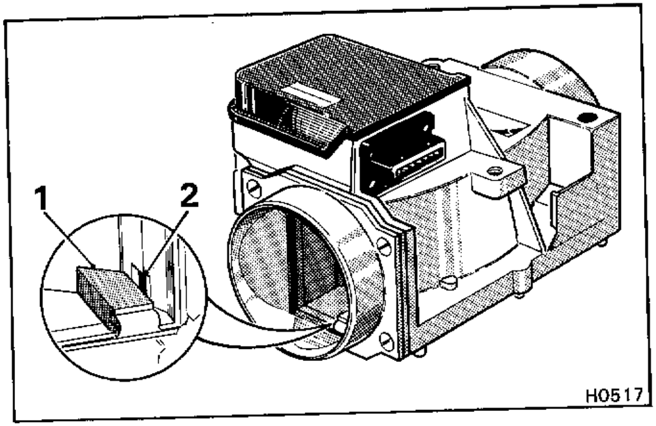

Fig. 8. Airflow meter

The mass of air drawn into the engine at any time is indicative of the engine load and a signal, proportional to the flap position, is passed to the E.C.U.

However, the air mass is related to air density which in turn is dependent upon air temperature. Therefore an air temperature sensor is incorporated into the airflow meter and this sends a separate electrical signal to the E.C.U.

Due to the action of the coil return spring, the airflow meter measuring flap (1) is almost closed when the engine is idling and an idle air by-pass (2) channel is provided to assist the engine to breathe at this low speed. Air passing through the by-pass channel is not registered by the airflow meter measuring flap.

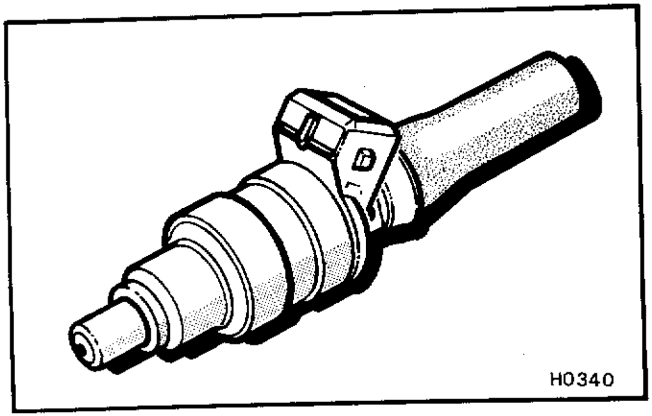

Fig. 9. Fuel injector

Fuel Injectors — Fig. 9

The injector consists of a solenoid-operated valve. The movable plunger is rigidly attached to the nozzle needle. In the closed position a helical compression spring holds the nozzle against the valve seat.

The solenoid winding is mounted in the rear section of the valve body, with the guide to the nozzle needle in the front section. The electrical pulses from the control unit are passed through a magnetic field. As a result, the plunger is attracted away from the nozzle seat allowing pressurized fuel to enter the inlet port.

The valve lift is approximately 0.15 mm (0.006 in) for the fully open position, and the response time about one millisecond. The amount of fuel delivered is governed by the period of time the injector is kept open. The exact injector 'open' time is dependent on a number of factors including rate of airflow, engine speed, engine temperature, inlet air temperature, atmospheric pressure, etc., but will be in the region of 1.5 to 10 milliseconds.

Throttle switches — Fig. 10
Throttle switches form part of the electronic control system and provide the E.C.U. with information on throttle operating conditions. Two types of switches can be used dependent upon the type of information required by the E.C.U. to perform its function.

A potentiometer-type switch is fitted to the engine plenum chamber in line with the throttle input spindle. This switch is a simple electrical potentiometer (variable resistance) whose electrical signal to the E.C.U. depends upon the position of the throttle spindle and hence the accelerator pedal. The E.C.U. will detect changes in throttle position by the voltage output from the potentiometer. Using this, together with information from the other sensors, it will adjust the fuel input accordingly, either for degrees of acceleration and deceleration or for constant engine speed. When acceleration is signalled to the E.C.U. by the throttle potentiometer, all injectors are pulsed to operate once simultaneously to ensure adequate engine reponse.

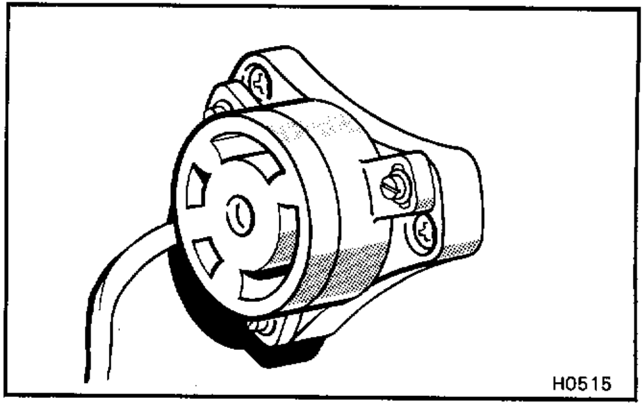

Fig. 10. **Potentiometer-type throttle switch**

Coolant temperature sensor—Fig. 11
This sensor is located between the cylinder heads and provides coolant temperature information to the E.C.U. This information causes the E.C.U. to lengthen the time that the main injectors are 'open', reducing this time as the engine warms up and cutting it off when normal engine operating temperature is reached. In practice, the sensor functions by modifying an output voltage from the E.C.U. through an 'earth' return circuit.

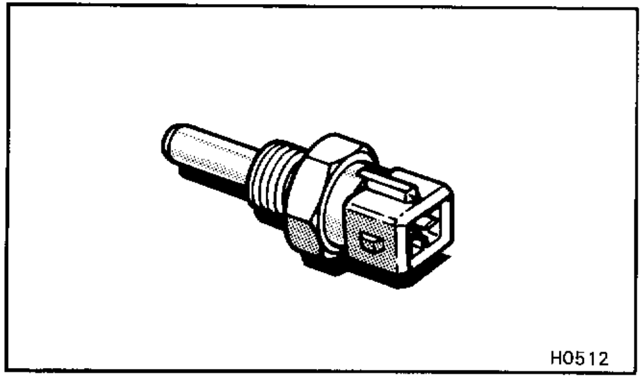

Fig. 11. **Coolant temperature sensor**

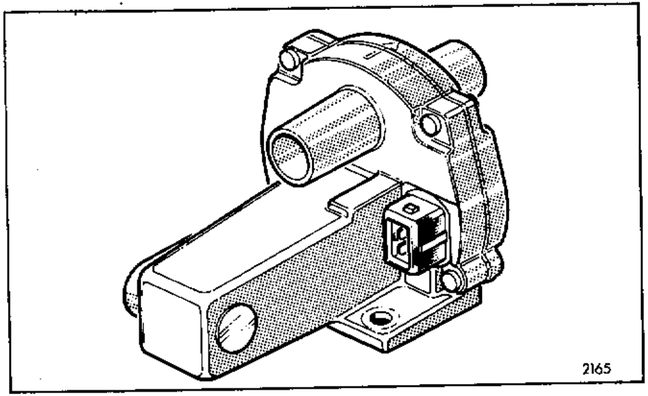

Fig. 12. Extra air valve

Extra air valve — Fig. 12
This valve is mounted above a water passage near the inlet manifold and registers the same temperature as the engine coolant. Its purpose is to provide the additional air required to maintain a satisfactory engine idle speed until the engine reaches normal operating temperature. Air is taken from a point before the throttle butterfly (but after the airflow meter, so that the air is registered by the E.C.U.) and returned to the plenum chamber after the throttle butterfly.

To allow air to pass through the extra air valve, and thus by-pass the throttle butterfly, an opening in a rotatable metal disc is aligned with the inlet and outlet tubes on the valve. The position of this disc is controlled by a bi-metal strip which deflects according to the temperature it experiences. As the bi-metal strip heats up it rotates the metal disc until its opening no longer lines up with the air valve tubes and the extra air source is reduced and finally terminated as normal engine operating temperature is reached.

The bi-metal strip is heated from two sources: the coolant temperature and a heater coil around the strip. The heater coil is energized from the fuel injection system combined relay while the engine is running.

Exhaust gas recirculation (E.G.R.) system — Fig. 13
To reduce the nitrous oxide (NOx) content in the exhaust, the peak combustion temperatures are lowered by recirculating a controlled quantity of the exhaust gases through the combustion process.

The E.G.R. valve is mounted on the exhaust manifold. A control signal, taken from a throttle edge tapping, gives no recirculation at idle or full load, but does allow an amount of recirculation, dependent on the vacuum signal and a metering profile on the valve under part-load conditions. Exhaust gas flows from the valve to the inlet plenum chamber via a lagged pipe.

Over-run valve
This second airflow control device bleeds air into the engine inlet manifold, via the plenum chamber, when the manifold depression is high and thus maintains combustion during engine over-run.

Function checks
Warm the engine to normal running temperature. Ensure that the idle speed returns to normal. Blip the throttle and observe the valve, which should open and close as the engine speed changes.

If the valve is not operating, remove the E.G.R. valve and check the valve operation using a vacuum test gauge. Fit a new E.G.R. valve if it is found to be defective.

Crankcase breathing
To ensure that piston 'blow by' gases do not escape from the crankcase to the atmosphere, a depression is maintained in the crankcase under all operating conditions. This is achieved by connecting the crankcase breathing housing to a point between the air meter flap and the throttle plate, i.e. a constant depression region.

Air is drawn into the left-hand rocker cover via an air filter and restrictor and drawn from the engine on the right-hand rocker cover. A flame trap is fitted in the draw-off housing.

Evaporative loss control system — Fig. 14
The function of this control system is to prevent fuel hydrocarbon vapours from entering the atmosphere. This is achieved by providing no direct external fuel tank breathing and venting the tank through an adsorption canister located in the engine compartment.

To prevent the canister flooding due to thermal expansion of any fuel in the tank, the tank filler neck is entered well down into the tank, and a pipe let into the tank at maximum fuel level vents into the filler neck to allow for fuel expansion. A liquid vapour separator is incorporated into the fuel tank vent pipe to reduce the quantity of vapour passed to the canister.

Any fuel vapour is purged from the canister once the engine is running by means of a connection to a constant depression region between the air meter flaps and the throttle butterfly.

WARNING: The use of compressed air to clean an adsorption canister or clear a blockage in the evaporative system is very dangerous. An explosive gas present in a partly saturated canister may be ignited by the heat generated when compressed air passes through the canister.

Maintenance
Maintenance of the fuel injection, emission and evaporative loss control system components is limited (the components being sealed units) to the routine checks as stated in the Maintenance Summary. Certain components, however, require renewal at predetermined intervals.

The fuel filter requires renewal at the interval as stated in the Maintenance Summary.

Should it be necessary to remove or renew an injector, a new sealing ring must be fitted.

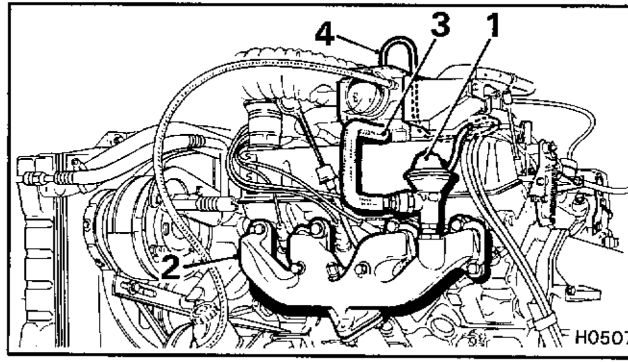

Fig. 13. E.G.R. system

Key to Fig. 13

1. E.G.R. valve
2. Exhaust manifold
3. E.G.R. pipe (asbestos lagged)
4. Throttle edge vacuum to E.G.R. valve

Checking the electronic fuel injection control system
Apart from the obvious functional checks possible as a result of reading the foregoing component and system descriptions, the detailed checking of the electronic control system for malfunction requires training and the use of special test equipment. It is therefore recommended that these checks are entrusted to your Dealer or to any service outlet that has the specialized knowledge and test equipment.

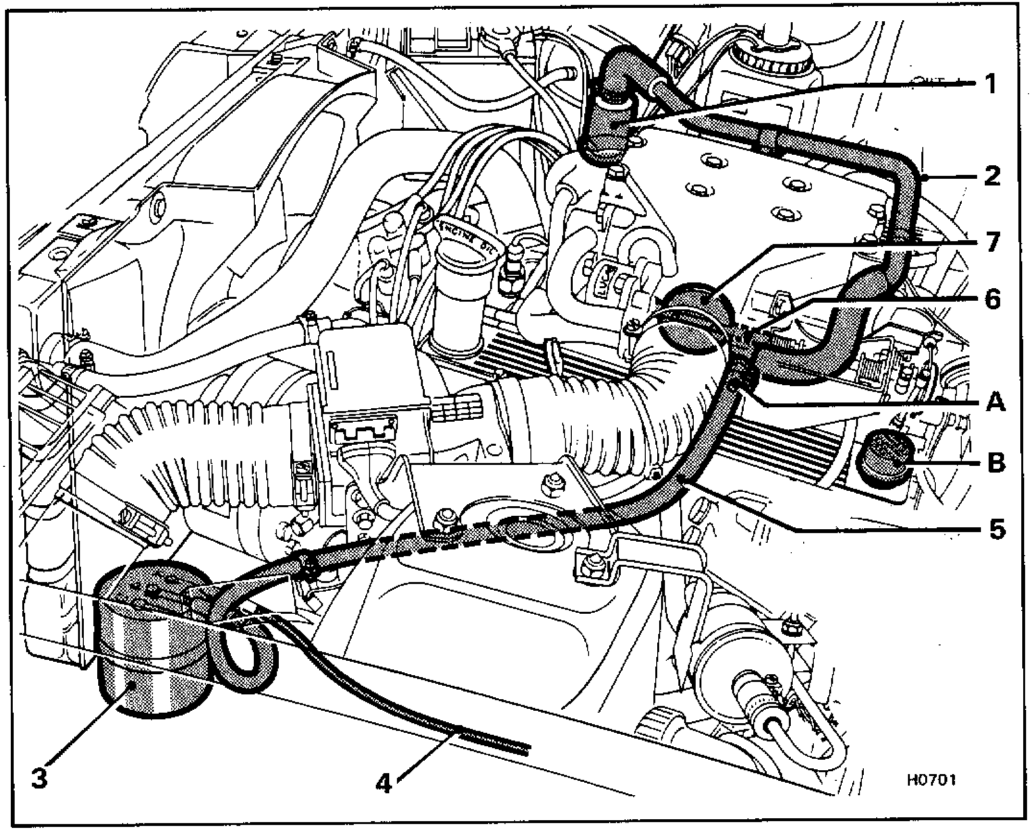

Fig. 14. Crankcase breathing and evaporative loss control systems

Key for Fig. 14

A. Purge point from charcoal canister to constant depression region, 3/32 in dia. restrictor fitted

B. Air inlet to engine crankcase, 0.040 in dia. restrictor fitted

1. Flame trap and engine crankcase purge point
2. Purge pipe engine crankcase to constant depression region
3. Charcoal canisters
4. Fuel tank vent pipe
5. Charcoal canister purge pipe to constant depression region
6. Throttle spindle
7. Throttle disc